# Popular Astronomy.

Vol. XXXVII, No. 5 MAY, 1929 Whole No. 365

## THE DISCOVERY OF LONG-PERIOD VARIABLE STARS.

(Second Paper)*

By PAUL W. MERRILL.

The first astronomical problems to attract attention were those connected with the apparent motions of the heavenly bodies. The daily rotation of the celestial sphere; the monthly motion of the moon and the changes in her appearance; the annual motion of the sun; the complicated motions of the major planets: these were all observed by the ancients, and their interpretation occupied a major part of the time of astronomers for centuries. Satisfactory explanations in terms of geometrical and physical laws finally became available through the combined labors of Hipparchus (190-125 B.C.), Ptolemy (about 140 A.D.), Copernicus (1473-1543), Tycho Brahe (1546-1601), Kepler (1571-1630), Galileo (1564-1642), Newton (1643-1727), and many others.

Systematic investigation of the brightness of the stars did not become a very important part of astronomy until the days of Argelander (1799-1875). This does not mean, however, that the subject had been wholly neglected before his time. Hipparchus and Ptolemy had classified hundreds of stars in six "magnitudes" according to their brightness. It is believed that the need of a star catalogue was suggested to Hipparchus about 130 B.C. by the sudden appearance of a new star in the constellation Scorpio. But if variable stars were known and studied in ancient and medieval times, no records, aside from a few references to novae, have come down to us.

About twenty long-period variables visible to the naked eye at times of greatest brightness are now known, but apparently only one, *o*, or Mira, Ceti was discovered before the invention of the telescope. It was found in 1596 but its periodicity was not recognized until 1639. Several of the twenty stars barely reach naked-eye visibility at maximum and require good conditions to be seen, but others are fairly conspicuous at times and it seems queer that the variations in *o* Ceti, R Leonis, $L_2$ Puppis, R Carinae, R Hydrae, and $\chi$ Cygni should have been overlooked for centuries. It seems reasonable to believe that the variations were actually noticed but that records of the observations were not made, or were not preserved, because their importance was not realized. We should not blame the early peoples too severely, for records could not formerly be made and kept with the same facility as today. Moreover, we cannot be certain that we are doing any better at the present time, for it is probable that in the year 3000 A.D. students will marvel

*The first paper was published in the February (1929) issue.

at our failure to observe certain things and to perceive the potential interest of some of the things we do observe.

Variable stars have generally been discovered by detecting changes in their brightness as compared with neighboring stars. The exact measurement of the light of an individual star, observed as an isolated object, is beset with so many practical difficulties that comparatively few stars have ever been observed in this way, and a large proportion of those so investigated were already known to be variable. But the determination of the *relative* brightness of a number of stars within a small area of the sky is very much easier. If every star in the sky should suddenly brighten by twenty per cent, very few astronomical observations would be capable of revealing this astonishing occurrence and it might remain unknown. But if only one star out of every ten should do so, astronomers would stand a good chance of detecting many of the variables. This is but one illustration of the very general fact that differential measurements are simpler and more certain than absolute ones. For the most part, then, the light of the stars has been studied by differential or relative methods.

TABLE I.

THE FIRST SIXTEEN VARIABLES DISCOVERED.

Those marked with an asterisk are typical long-period variables.

| | R.A. 1900 h m | Dec. 1900 ° ′ | Mag. | Period Days | Discoverer | Date |
|---|---|---|---|---|---|---|
| 1. *o* Ceti* | 2 14.3 | — 3 26 | 1.7- 9.6 | 331.7 | Fabricius | 1596 |
| 2. β Persei | 3 1.7 | +40 34 | 2.1- 3.2 | 2.9 | Montanari | 1669 |
| 3. χ Cygni* | 19 46.7 | +32 40 | 4.0- 13.5 | 406.0 | Kirch | 1686 |
| 4. R Hydrae* | 13 24.2 | —22 46 | 4.0- 9.8 | 425.2 | Maraldi | 1704 |
| 5. R Leonis* | 9 42.2 | +11 54 | 4.6- 10.5 | 312.8 | Koch | 1782 |
| 6. η Aquilae | 19 47.4 | + 0 45 | 3.7- 4.5 | 7.2 | Pigott | 1784 |
| 7. β Lyrae | 18 46.4 | +33 15 | 3.4- 4.1 | 12.9 | Goodricke | 1784 |
| 8. δ Cephei | 22 25.4 | +57 54 | 3.7- 4.6 | 5.4 | Goodricke | 1784 |
| 9. α Herculis | 17 10.1 | +14 30 | 3.1- 3.9 | Irreg. | W. Herschel | 1795 |
| 10. R Coronae | 15 44.4 | +28 28 | 5.5- 12.5 | Irreg. | Pigott | 1795 |
| 11. R Scuti | 18 42.2 | — 5 49 | 4.8- 7.8 | Irreg. | Pigott | 1795 |
| 12. R Virginis* | 12 33.4 | + 7 32 | 6.4- 12.1 | 145.5 | Harding | 1809 |
| 13. R Aquarii* | 23 38.6 | —15 50 | 6.2- 11.0 | 387.2 | Harding | 1811 |
| 14. R Serpentis* | 15 46.1 | +15 26 | 5.6- 13. | 357.2 | Harding | 1826 |
| 15. S Serpentis* | 15 17.0 | +14 40 | 7.8- 14.0 | 368.5 | Harding | 1828 |
| 16. R Cancri* | 8 11.0 | +12 2 | 6.0- 11.3 | 362. | Schwerd | 1829 |

Data largely from *Annals Harvard College Observatory*, volume 56.

Until the latter part of the nineteenth century, variable stars were found either by general observation of the sky or in connection with the formation of star charts and catalogues. But with the application of the photographic plate and the spectroscope to astronomical research, efficient systematic methods of detecting variables became available and have produced rich results. These methods are by far the most important now in use but the history of the subject will be better displayed if we postpone their consideration until the older work has been described.

The great changes in brightness characteristic of long-period vari-

ables make the discovery of these objects relatively easy. Their redness is also a factor in attracting the attention of observers and in raising an *a priori* suspicion of variability. Thus it happened that of the first sixteen variable stars to be discovered, nine are typical long-period variables. (See Table I.)

It may be of interest to give some particulars concerning the discovery and early history of the first four long-period variables. They were found prior to the year 1800 and thus long before the development of the photographic and spectroscopic methods. These four objects, moreover, are the only long-period variables discovered before 1800. During the nineteenth century, 223 were found, 131 of them during the last decade.

o *Ceti (Mira).* On the night of August 13, 1596, Fabricius[1] noticed that this star was brighter than α Arietis, a yellow star of magnitude 2.2. He observed it again during the first few days of September and followed it until it vanished from sight sometime in October. As it was in excellent observing position at this time, the observed diminution of light was doubtless real. Apparently all his observations were on the decreasing portion of the light curve. Maximum probably occurred about the end of June, 1596. The next fact to be recorded seems to us a strange one. It is that twelve years were allowed to elapse before further observations were made. According to the record, Fabricius saw Mira for the second time on February 15, 1609. Whether he looked for it during this long interval we do not know. Mira is in the most favorable position for observation during the autumn of each year, coming to opposition[2] during the last days of October. As the period between its light maxima is about eleven months, it would have been faint during the autumn for several years following 1596 so that Fabricius, if he looked for it, might have been unable to see it, and perhaps entertained no idea of the recurrence of its visibility. It should have been easy to observe, however, during the years 1602 to 1605.

The next recorded observation was in 1631. On October 14 of that year Schickard saw it as bright as α Ceti, a neighboring red star of magnitude 2.8. In December, 1638, the variability was discovered independently by Holwarda and Fullenius. Since that time observations have been made nearly every year. This star occurs in Bayer's famous star chart "Uranometria" published in 1603. Bayer, ignorant of the variability in light, assigned it the Greek letter omicron by which it is still known. Hevelius later gave it the special name Mira.[3] because of its wonderful changes in light.

χ *Cygni.* In July, 1686, G. Kirch[4] looked at the new star in Vulpecula which had been discovered in 1670, and took the occasion to compare

[1] David Fabricius (1564-1617), a German clergyman.
[2] On the meridian at midnight.
[3] Latin word for wonderful.
[4] A German astronomer (1639-1710).

the surrounding part of the sky with the charts of Bayer and Hevelius. In this way he noticed the absence of a star in Cygnus which had been marked $\chi$ by Bayer. He kept the region under continued observation and on October 19, 1686, was rewarded by finding the star to be of the fifth magnitude, thus discovering its variability. He and other members of his family followed the star until 1738.

*R Hydrae.* This star does not occur in the regular edition of Bayer's chart (1603) but had been put in by hand by Montanari as of the fourth magnitude. His observations were made in April, 1670. Still earlier observations by Hevelius on April 18 and 19, 1662, had caused him to include this star in his catalogue, assigning it to the sixth magnitude. Neither of these observers appears to have recognized any changes. The credit for discovering the variability seems to belong to Maraldi.[5] He saw Montanari's record on the Bayer chart and searched for the star in 1702 but failed to find it. He saw it for the first time in 1704 as of the fourth magnitude, and between then and 1712 he observed several appearances and disappearances.

*R Leonis.* The following is a translation of part of a letter dated January 14, 1785 from D. Koch of Osnabrück to J. E. Bode, Astronomer of the Berlin Observatory, published in 1785 in the *Berliner Astronomishes Jahrbuch* for 1788.

"I take the liberty, sir, to communicate to you several observations which I have made, in various years, of the 420th star in Mayer's Zodiacal Star Catalogue (106 Leonis in my own complete star catalogue) which seem to me to be of some importance. This star, whose right ascension for 1756.0 in Mayer's Catalogue is 143° 36′ 50″ ($9^h\ 34^m\ 27^s.3$), declination +12° 33′ 4″.1, has exhibited very considerable variation of its apparent magnitude. In the year 1780 when I first looked at it in a telescope I estimated it to be of the seventh magnitude, and it was then noticeably fainter than the neighboring star Mayer 419, which is identical with 19 Leonis according to Flamsteed. In February, 1782, it was of the sixth magnitude and visible to the naked eye. At the end of April, 1783, it was of the ninth magnitude, and at the beginning of April, 1784, of the tenth. At present, however, it is so faint that I am unable to recognize it with a good 16-inch Gregorian telescope. This telescope is the best which has served for my observations. To be sure, I possess a better one but on account of its length I have not been able to use it as yet. It would be agreeable to me, sir, if in connection with the observations of this star you would take a few moments to ascertain to what extent it is visible in better telescopes than the one mentioned."

A foot note added to the letter says, "On February 27 and 28, 1785, I directed my three and a half foot Doll.[6] telescope toward the position of the star Mayer 420 (R Leonis) but could see no trace of a star."

[5] Italian astronomer (1665-1729).
[6] Dollond?

TABLE II.

LONG-PERIOD VARIABLES DISCOVERED PRIOR TO 1860.

| | R.A. 1900 h m | Dec. 1900 ° ′ | Mag. | Period Days | Discoverer | Date |
|---|---|---|---|---|---|---|
| 1. R Androm. | 0 18.8 | +38 1 | 6.0- 14.9 | 410.7 | (Bonn) | 1858 |
| 2. S Piscium | 1 12.4 | + 8 24 | 8.2-[14.7 | 404.3 | Hind | 1851 |
| 3. R Piscium | 1 25.5 | + 2 22 | 7.6- 13.5 | 344.2 | Hind | 1850 |
| 4. R Arietis | 2 10.4 | +24 35 | 7.5- 13.7 | 186.6 | (Bonn) | 1858 |
| 5. o Ceti | 2 14.3 | — 3 26 | 1.7- 9.6 | 331.7 | Fabricius | 1596 |
| 6. R Tauri | 4 22.8 | + 9 56 | 8.0- 14.0 | 325. | Hind | 1849 |
| 7. S Tauri | 4 23.7 | + 9 44 | 9.5- 14.6 | 365. | Oudemans | 1855 |
| 8. R Orionis | 4 53.6 | + 7 59 | 8.7- 13.5 | 378.5 | Hind | 1848 |
| 9. R Leporis | 4 55.0 | —14 57 | 6.1- 9.7 | 436.1 | Schmidt | 1855 |
| 10. R Gemin. | 7 1.3 | +22 52 | 6.4- 13.8 | 370.2 | Hind | 1848 |
| 11. R Can. Min. | 7 3.2 | +10 11 | 7.2- 10.0 | 337.7 | (Bonn) | 1855 |
| 12. S Can. Min. | 7 27.3 | + 8 32 | 7.0- 12.2 | 330.3 | Hind | 1856 |
| 13. S Gemin. | 7 37.0 | +23 41 | 8.2- 14.5 | 294. | Hind | 1848 |
| 14. T Gemin. | 7 43.3 | +23 59 | 8.1-[13.5 | 288.1 | Hind | 1848 |
| 15. U Gemin. | 7 49.2 | +22 16 | 8.9- 14.0 | 893. | Hind | 1855 |
| 16. R Cancri | 8 11.0 | +12 2 | 6.0- 11.3 | 362. | Schwerd | 1829 |
| 17. U Cancri | 8 30.0 | +19 14 | 8.4-[14.0 | 305.0 | Chacornac | 1853 |
| 18. S Hydrae | 8 48.4 | + 3 27 | 7.5- 13.0 | 256. | Hind | 1848 |
| 19. T Hydrae | 8 50 8 | — 8 46 | 7.0- 13.1 | 288.8 | Hind | 1851 |
| 20. T Cancri | 8 51.0 | +20 14 | 8.0- 10.8 | 482. | Hind | 1850 |
| 21. R Leonis | 9 42.2 | +11 54 | 4.6- 10.5 | 312.8 | Koch | 1782 |
| 22. R Urs. Maj. | 10 37.6 | +69 18 | 7.0- 13.5 | 302.1 | Pogson | 1853 |
| 23. S Leonis | 11 5.7 | + 6 0 | 9.0- 13.5 | 189.5 | Chacornac | 1856 |
| 24. R Com. Ber. | 11 59.1 | +19 20 | 8.0- 15.0 | 361.8 | Schönfeld | 1856 |
| 25. T Virginis | 12 9.5 | — 5 29 | 8.7- 13.5 | 339.5 | Boguslawski | 1849 |
| 26. S Urs. Maj. | 12 39.6 | +61 38 | 7.3- 12.5 | 226.5 | Pogson | 1853 |
| 27. U Virginis | 12 46.0 | + 6 6 | 7.5- 13.5 | 206.9 | Harding | 1831 |
| 28. V Virginis | 13 22.6 | — 2 39 | 8.0- 14.0 | 250.5 | Goldschmidt | 1857 |
| 29. R Hydrae | 13 24.2 | —22 46 | 4.0- 9.8 | 425.2 | Maraldi | 1704 |
| 30. S Virginis | 13 27.8 | — 6 41 | 5.6- 12.3 | 376.9 | Hind | 1852 |
| 31. R Camelop. | 14 25.1 | +84 17 | 7.9- 13.7 | 269.5 | Hencke | 1858 |
| 32. R Bootis | 14 32.8 | +27 10 | 6.6- 12.9 | 223.3 | (Bonn) | 1858 |
| 33. S Serpentis | 15 17.0 | +14 40 | 7.8- 14.0 | 368.5 | Harding | 1828 |
| 34. R Serpentis | 15 46.1 | +15 26 | 5.6- 13. | 357.2 | Harding | 1826 |
| 35. R Librae | 15 47.9 | —15 56 | 9.2-[13. | 242.4 | Pogson | 1858 |
| 36. R Herculis | 16 1.7 | +18 38 | 8.6- 14.8 | 317.7 | (Bonn) | 1855 |
| 37. S Scorpii | 16 11.7 | —22 39 | 9.1- 15. | 176.7 | Chacornac | 1854 |
| 38. R Scorpii | 16 11.7 | —22 42 | 9.5- 16. | 224.1 | Chacornac | 1853 |
| 39. S Ophiuchi | 16 28.5 | —16 57 | 8.3-[13. | 233.8 | Pogson | 1854 |
| 40. S Herculis | 16 47.4 | +15 7 | 7.3- 12.6 | 308.3 | (Bonn) | 1856 |
| 41. R Ophiuchi | 17 2.0 | —15 58 | 7.1- 13.6 | 302.2 | Pogson | 1853 |
| 42. T Herculis | 18 5.3 | +31 0 | 7.2- 13.6 | 165.0 | (Bonn) | 1857 |
| 43. R Aquilae | 19 1.6 | + 8 5 | 5.8-[12. | 355.0 | (Bonn) | 1856 |
| 44. R Sag. | 19 10.8 | —19 29 | 6.9- 12.3 | 269.0 | Pogson | 1858 |
| 45. R Cygni | 19 34.1 | +49 58 | 6.6- 13.9 | 425.9 | Pogson | 1852 |
| 46. χ Cygni | 19 46.7 | +32 40 | 4.0- 13.5 | 406.0 | Kirch | 1686 |
| 47. R Cap. | 20 5.7 | —14 34 | 9.0-[13. | 344. | Hind | 1848 |
| 48. R Delph. | 20 10.1 | + 8 47 | 7.6- 13.0 | 284.4 | Hencke | 1851 |
| 49. U Cap. | 20 42.6 | —15 9 | 10.2- 14. | 202.5 | Pogson | 1857 |
| 50. R Vulpec. | 20 59.9 | +23 26 | 7.5- 12.1 | 136.8 | (Bonn) | 1858 |
| 51. T Cap. | 20 16.5 | —15 35 | 8.8- 13.5 | 269.2 | Hind | 1854 |
| 52. S Cephei | 21 36.5 | +78 10 | 7.9- 13.1 | 485.8 | Hencke | 1858 |
| 53. S Aquarii | 22 51.8 | —20 53 | 8.0- 14.2 | 279.7 | Argelander | 1853 |
| 54. R Pegasi | 23 1.6 | +10 0 | 7.5- 13.2 | 377.5 | Hind | 1848 |
| 55. R Aquarii | 23 38.6 | —15 50 | 6.2- 11.0 | 387.2 | Harding | 1811 |
| 56. R Cass. | 23 53.3 | +50 50 | 5.3- 12.8 | 431.6 | Pogson | 1853 |

Data from *Annals Harvard College Observatory*, volume 56.

Table II contains a list of all variables definitely recognized to have long periods, which were discovered prior to 1860.

With the introduction of photography as a method of star charting, the discovery of variables was greatly facilitated. The images of hundreds or even thousands of stars may appear on a single negative and the intensity of each one can, by means of a special optical comparator, be quickly compared with that on another plate of the same region taken at a different time. Moreover, it was not long after the general adoption of the photographic plate as a standard astronomical tool that a remarkable new method of detecting long-period variables by a single observation was discovered. This method depends on the fact that a particular type of spectrum is a positive indication of long-period variability. Its importance may be realized from the fact that present catalogues contain nearly 450 objects whose variability could be predicted by an expert from a glance at the photographed spectrum. And there are a number of other stars whose spectra would raise a presumption of variability.

The historical progress in the discovery of variables may be seen from the following list of variable star catalogues and the number of stars contained in each.

CATALOGUES OF VARIABLE STARS.

| Year | Compiler | No. of Stars |
|---|---|---|
| 1786 | Pigott | 12 |
| 1844 | Argelander | 18 |
| 1850 | Argelander | 24 |
| 1854 | Pogson | 53 |
| 1865 | Chambers | 113 |
| 1875 | Schönfeld | 143 |
| 1884 | Gore | 191 |
| 1888 | Gore | 243 |
| 1893 | Chandler | 260 |
| 1896 | Chandler | 393 |
| 1903 | Pickering | 701 |
| 1907 | Cannon | 1380 |
| 1915 | Müller and Hartwig | 1687 |
| 1928 | Prager | 3218 |

These catalogues contain variables of all types, with short as well as long periods, but omit those in the Magellanic clouds, globular clusters, and spiral nebulae. Altogether five or six thousand variable stars are now known, of which 1760 are listed as long-period variables.

The Harvard College Observatory has been the great pioneer in the systematic discovery of variable stars, chiefly by photographic and spectroscopic methods. The earliest Harvard discoveries were, however, made visually. The first variable discovered at Harvard was T Orionis (1900 R.A. $5^h\ 30^m.9$; Dec. $-5°\ 32'$; Mag. 9.0-13.0; Period irregular) found in 1863 by Professor George P. Bond in connection with his extensive study of the region of the Orion nebula. The second and third, U Puppis (1900 R.A. $7^h\ 56^m.1$; Dec. $-12°\ 34'$; Mag. 8.5-14.5; Period 315 days; Spectrum M5e) and R Ursae Minoris (1900 R.A. $16^h\ 31^m.3$;

Dec. +72° 28′; Mag. 8.6-10.5; Period 320 days; Spectrum M7) were found in 1881 by Professor E. C. Pickering. For both of these the variability was at first suspected from the character of the spectrum, which was observed visually. About 1886 a program for the wholesale photography of stellar spectra was inaugurated by Professor Pickering. His method, reverting to that of Fraunhofer, was to photograph the sky through a large prism placed in front of the object glass of the telescope. Each star is thus photographed not as a point image but as a narrow spectrum half an inch or so long.

The first star to be identified as a long-period variable from a photograph of its spectrum was U Orionis (1900 R.A. $5^h49^m.9$; Dec. +20° 10′; Mag. 6.0-11.8; Period 372.2 days; Spectrum M6e). Upon its discovery by Gore on December 13, 1885, it was first thought to be a nova, but on December 16 a photograph of its spectrum taken at the Harvard Observatory showed a strong similarity to that of o Ceti, photographed for the first time only five days previously, and it was accordingly assigned to the long-period class of variables. The first star for which variability was inferred from the character of the photographed spectrum is R Caeli (1900 R.A. $4^h\ 37^m.0$; Dec. −38° 26′; Mag. 8.3-13.0; Period 394 days; Spectrum M6e) found in 1890 by Mrs. Fleming at the Harvard Observatory. Thus the Harvard College Observatory has to its credit the following pioneer achievements in the spectroscopy of long-period variable stars:

| Year | Star | |
|---|---|---|
| 1881 | U Puppis and R Ursae Minoris | First stars for which variability was inferred from the character of the spectrum observed visually. |
| 1885 | o Ceti | First photograph of the spectrum of a long-period variable. |
| 1885 | U Orionis | First variable assigned to the long-period class from the character of its photographed spectrum. |
| 1890 | R Caeli | First star for which variability was inferred from the character of its photographed spectrum. |

At the present time the lists of long-period variables are reasonably complete only for the brighter stars, including the eight or perhaps the ninth magnitude. Below the ninth, and especially below the tenth magnitude, relatively few are known, though thousands upon thousands doubtless await discovery. Shapley and Waterfield estimate that only about one-half of the variables brighter than the eleventh magnitude have been found, while for fainter magnitudes the proportion is, of course, far less.

The importance of discovering additional faint variables while perhaps not very obvious, is nevertheless really considerable. It is true that only the brighter objects can be studied in detail by spectroscopic and precise photometric methods and that variables already known furnish extensive opportunity for work of this kind. But it is possible

that among future discoveries will be found new or abnormal types of variability of especial interest, for example stars with longer periods or greater ranges than any now known. Some of the new long-period stars might prove to have lower surface temperatures than any stars so far studied. If such very cool stars exist it is clearly very important to find and study them for their bearing on the problems of stellar evolution.

The discovery of long-period variables, moreover, is now being emphasized in a totally different connection, namely, for the assistance they may render in determining the distances of special objects such as Milky Way clouds, spiral nebulae, and star clusters, which are too far away to yield to ordinary parallax methods. We have recently gained a fairly accurate knowledge of the average intrinsic brightness of a long-period variable at maximum, and by comparing this with the apparent brightness of a particular variable an approximate determination of its distance is at once obtained. The faintest stars are of the most interest because they are probably the most distant. This method is being extensively applied by Dr. Harlow Shapley and the staff of the Harvard College Observatory to the star clouds in the Milky Way.

## The Designations of Variable Stars.

Argelander introduced the use of the capital roman letters R to Z as designations of variables within each constellation.[7] This system allowed for only nine variables in each constellation, and in time had to be extended. The method adopted by the *Astronomische Gesellschaft* and now in general use will be obvious from the following table.

| | |
|---|---|
| 1. R | — |
| 2. S | — |
| — | 54. ZZ |
| — | 55. AA |
| 9. Z | 56. AB |
| 10. RR | — |
| 11. RS | — |
| — | 79. AZ* |
| — | 80. BB |
| 18. RZ | 81. BC |
| 19. SS | — |
| 20. ST | — |
| — | 334. QZ |
| — | 335. V335 |
| 26. SZ | 336. V336 |
| | — |
| | — |
| | ad inf. |

The letters are assigned in each constellation in order of discovery. Thus in the constellation Aurigae, the first variable found is R Aurigae,

[7] For stars that previously had been named, he kept the old names and did not assign new ones, *e.g.* o Ceti, $\beta$ Persei, $\chi$ Cygni.

*The letter J is omitted throughout.

the nineteenth, SS Aurigae; the three hundred and thirty-fifth will be V335 Aurigae, etc.

In 1888 Chandler suggested that the numbers for variable star catalogues be one-tenth of the right ascension, expressed in time-seconds, for the equinox 1900.0. Thus

| Variable | R.A. 1900.0 | | | | Chandler No. |
|---|---|---|---|---|---|
| | h | m | s | s | |
| o Ceti | 2 | 14 | 18 | = 8058 | 806 |
| R Leonis | 9 | 42 | 11 | = 34931 | 3493 |
| χ Cygni | 19 | 46 | 44 | = 71204 | 7120 |

These numbers are found on the Hagen charts and in many of the older lists of variables but are not now in common use.

A method devised at the Harvard Observatory twenty-five years ago to give in compact form the approximate position of a variable has proven very convenient and is now widely used. Six figures are employed to give the position for 1900.0. The first two give the hour of right ascension; the second two the minute of right ascension; and the last two the degree of declination. Thus for R Leonis (1900 R.A. $9^h$ $42^m.2$; Dec. $+11°$ 54′) the designation is 094211. If the declination is south, the number is italicized. Thus o Ceti (1900 R.A. $2^h$ $14^m.3$; Dec. $-3°$ 26′), *021403*.[8]

The variables found at the Harvard Observatory have been given the designation HV1, HV2, HV3, etc., in order of discovery. Some of these are later assigned constellation letters according to the *Astronomische Gesellschaft* system, but for the numerous faint variables in special regions the HV numbers may serve as the permanent designations.

General References.

1. J. G. Hagen, S. J., *Die Veränderliche Sterne*, Freiburg 1913.
2. G. Müller and E. Hartwig, *Geschichte und Literatur des Lichtwechsels*, etc., Leipzig 1918.
3. *Annals Harvard College Observatory*, vols. 55; 56, Table IX, p. 197; 79, part 3, p. 161, Catalogue of Long Period Variable Stars.

[8] In a recent Harvard catalogue the figures for the declination only are italicized, thus, 0214*03*.

Carnegie Institution of Washington, Mount Wilson Observatory.

## CAPRICORNUS.

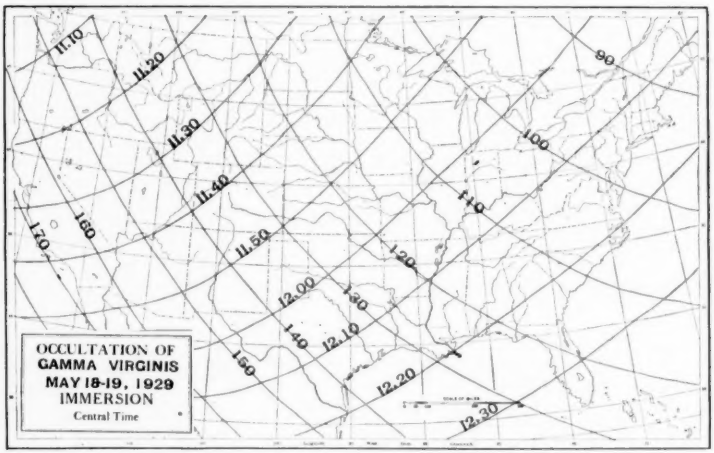
Once, as the gods were feasting while
Sojourning by the river Nile
Huge Typhon scared them. Off they ran
And one dived eastward to escape:
Since then he wears a sea-goat's shape
Who really is the great god, Pan.

1490 Stuart St., Denver, Colorado. Lilian White Spencer.

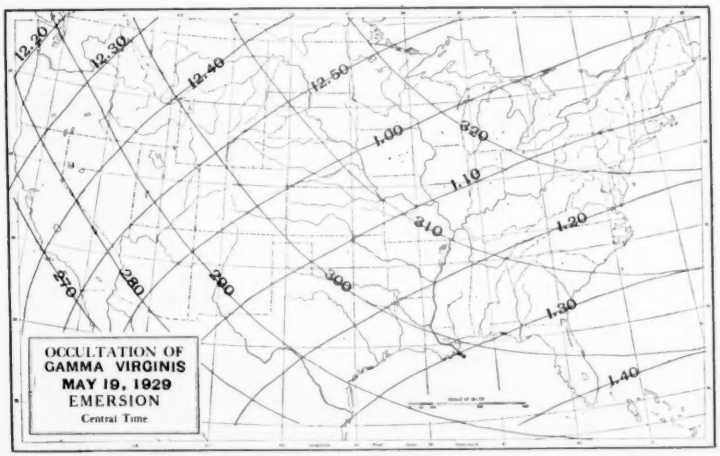
## OCCULTATION OF GAMMA VIRGINIS, MAY 18-19, 1929.

By WM. CLETUS DOYLE, S. J.

Since it will occur over four days before full moon, this occultation of Gamma Virginis can be observed even in a very small telescope. The




times of disappearance (at the dark limb) vary from 11:10 P.M. (Central Time) in the state of Washington to 12:30 A.M. in Florida. The



position angles (given in degrees east from the north point of the moon) will be between 90 and 170 degrees. The times of reappearance vary from 12:20 A.M. in the state of Washington to 1:40 A.M. in Florida, the position angles from 270 to 330 degrees. The star is approximately of the third magnitude.

CREIGHTON UNIVERSITY OBSERVATORY, OMAHA, NEBRASKA.

## AMERICAN ASTRONOMICAL SOCIETY.

## ABSTRACTS OF PAPERS

### APPLICATION OF CORRELATION PERIODOGRAM TO R LYRAE.

BY DINSMORE ALTER.

This star is a very difficult variable to observe, but is one on which a great deal of work has been done during the last seventy years.

Data collected by B. Okouneff (*A.N.*, No. 5458) have been analysed by means of the correlation periodogram. A period, probably complex, of 67⅔ days exists but accounts for only a minor portion of the total light variation. It will require the analysis of many more data to tell whether or not the star is periodic beyond this slight amount.

No evidence is found for a variable period as suspected by Okouneff and others.

### DOUBLE STARS IN THE OXFORD ASTROGRAPHIC CATALOGUE.

BY S. G. BARTON.

The paper reported the discovery of 236 new double stars separated by 5″ or less and the determination of the angle and distance of these and of 276 known pairs from the data of the Oxford Astrographic Catalogue.

### THE SPECTRA OF ASTEROIDS.

BY N. T. BOBROVNIKOFF.

The spectra of twelve brighter asteroids have been obtained by the writer at the Lick Observatory. The spectra of all twelve have been obtained in the photographic region and of two—Ceres and Vesta—in the visual region. Two G0-type stars, λ Serpentis and 15 Sagittae, have been photographed for comparison.

The spectra in the photographic region show no lines or bands other than those of solar origin, but in the continuous background they differ from the solar spectrum and among themselves and show considerable variations. This is interpreted as an effect of rotation.

The spectra of most asteroids show a weak violet part as compared with G0-type stars. This is attributed to low reflectivity in this region, and may be due to the presence of iron and iron sulphates, the prominent constituents of meteorites. This and the similarity of cometary spectra suggest the kinship of asteroids with comets and meteorites.

The full paper will appear in a *Lick Observatory Bulletin.*

## THE RÔLE OF ASTRONOMY IN GEODESY.

By William Bowie.

The primary function of the geodesist is to determine the shape and size of the earth but, without the accumulated results obtained by astronomers, this problem of the geodesists could not be solved. The positions of stars are determined by the astronomers and published in star catalogues. The stars are then used by the geodesists in locating points over the earth's surface. By connecting the points at which astronomical observations for latitude and longitude are made by a series of direct measurements over the ground or by means of triangulation, the curvature of the earth for different latitudes is obtained and from these data the shape and size of the earth are derived.

A number of figures of the earth have been derived from astronomical and geodetic data in the past and the one that is considered to be the most reliable one is called the Hayford spheroid. This was derived from data in the United States. A novel feature of the work of Hayford in this connection was the application of the principle of isostasy to the astronomical observations.

As arcs of triangulation have been extended across country to furnish geographic positions for surveying, mapping, and scientific work, it is essential that the directions of certain lines of triangulation should be obtained from observations on Polaris, if the work is done in the northern hemisphere. The irregularities in the surface of the earth affect these azimuth observations because the vertical axis of the instrument used is tilted towards mountain and continental masses and away from valleys and ocean areas. By an ingenious method the tilting of the meridian at the point of observation is computed and corrections are applied to the azimuth observations on Polaris, then a true north and south line can be obtained which is referred to the spheroid rather than to the equipotential surface represented by sea level, called the geoid.

By the use of these corrected azimuths, called Laplace azimuths, it is possible to measure distances across country with an incredible degree of accuracy. Many of these Laplace azimuths were used in the adjustment of the 13,000 miles of arcs of triangulation in the western half of the United States. The correction to the distance between junction points of the triangulation net resulting from the adjustment averaged

about one part in 300,000 of the distance. This is at the rate of about one-fifth inch per mile.

In the near future it is hoped that another figure of the earth will be derived from the triangulation of the United States, Canada, and Mexico. These three countries have combined their triangulation nets, thus making it possible to secure a larger area and greater range in latitude than have ever been used before.

## THE LAMONT EXPEDITION.

By R. H. Curtiss.

The Lamont-Hussey Observatory of the Lamont Expedition has been productively engaged upon its astronomical program at Bloemfontein, South Africa, since April, 1928. The building contains three offices, a strong room and a library in one wing, and garage, store room and quarters for native helper in the other. Between the two wings a circular section supports the 56-foot dome of the Lamont telescope. This refractor has an aperture of 27 inches and a focal length slightly greater than forty feet. It is proving to be a very successful instrument.

The purpose of the Expedition is to complete the Lick survey of double stars. To that end the Expedition is conducting a systematic search and is coöperating with the Union Observatory under a division of the sky. The limiting magnitude of the primary star in a pair has been extended to 9.5 magnitude in the Expedition's survey as compared with Hussey's limit of 9.1 in the northern skies. Measures with the 27-inch are confined to Aitken's definition limits of separation when seeing permits and under Aitken's catalog limits, at most, at other times. Under the definition limits, 535 new doubles have been discovered at the Lamont-Hussey Observatory to date.

## REPORT ON RT PERSEI.

By Raymond S. Dugan.

The period of the occurrence of primary minimum of the eclipsing variable RT Persei has remained sensibly constant from 1916 to 1928, at a value about 1.85 seconds shorter than that of the period found in 1907. The change from one value to the other appears to have been gradual. The observations of secondary minimum prove that the major part of the variation in period is not due to a revolution of the line of apsides.

## CONTOURS OF SOME LINES IN THE SPECTRUM OF 7$\epsilon$ AURIGAE.

By C. T. Elvey.

Spectrograms of the eclipsing variable 7 $\epsilon$ Aurigae, taken with the three-prism spectrograph of the Yerkes Observatory, have been analysed with a registering microphotometer. From Aug. 9 to Dec. 9,

1928, ten plates were taken, each having been standardized with a new sensitometer of variable apertures. The density-curves show that the lines of the earlier plates are unsymmetrical, the sharper edge being on the red side of the line. The last plate taken, which is certainly within the phase of constant minimum light, shows the lines to be quite symmetrical.

The ratios of the areas of the violet sides of the lines to the red sides have been taken as a measure of the asymmetry of the line. The contours and the ratios have been measured for the lines: Fe+ 4515, Fe+ 4541, Ti+ 4563, and Ti+ 4572. The ratios on Apr. 28, Oct. 29, Nov. 6, 12, 24, Dec. 5, and 9, are, respectively: Fe+ 4515, 1.4, 1.6, 1.2, 1.6, 1.5, 1.0, and 1.0; Fe+ 4541, 1.2, 1.1, 1.1, 1.4, 1.3, 0.8, and 0.8; Ti+ 4563, 1.1, 1.1, 0.9, 1.3, 0.9, 0.8, and 0.8; Ti+ 4572, 1.2, 1.4, 1.6, 1.2, 1.4, 1.0, and 1.0.

The asymmetry of the lines seems to be due to a widening of the violet sides of the lines, just as though a fainter component were present but not resolved by the spectrograph. This, however, as has been pointed out by Ludendorff, would not be possible in a simple eclipsing system, for the component would have been recognized at the times of maximum difference in velocity of the two stars. The lines on the plate of Dec. 9 are of about the same width and sharpness as on plates taken in 1922. The earlier plates are not standardized and as yet no attempt has been made to obtain the contours of the lines.

These preliminary results do not seem to support the hypothesis that the asymmetry is due to the rotation of the eclipsed star. There is the possibility that the asymmetry may be associated with the 150-day period rather than with the longer period. Series of spectrophotometric observations through the minimum phase will probably settle this point.

## THE DUPONT-PATHÉ PANCHROMATIC PLATE.

By Philip Fox and O. J. Lee.

For many spectrographic problems it is desirable to photograph a long range of the spectrum in one exposure. To accomplish this it is essential that the spectrograph should at one setting give this range in good focus and that the plate should be so adapted that it will give uniform intensity of image throughout the range. The single-prism spectrograph of the Dearborn Observatory gives photographs in sharp focus from $\lambda$ 3700 to $\lambda$ 6800 and perhaps even farther. Titanium lines at $\lambda$ 3706 and $\lambda$ 6258 and H$\alpha$ at 6563 and all intermediate lines are simultaneously in sharp focus.

Through the courtesy of the Redpath Laboratory of the DuPont-Pathé Film Mfg. Co. at Parlin, N. J., we were supplied with hand-coated plates of their panchromatic emulsion. The performance of this emulsion in connection with our spectrograph when exposed to the sky

yields a spectrum of practically uniform intensity reaching from Hα to Hε. There is a slight weakening in the green but the photograph is usable for the detailed study and measurement of lines throughout this range. For stellar spectra similar uniformity is attainable by appropriate focussing of the telescope.

Using integrated light of the standard intensity areas now impressed on all the Dearborn Observatory spectrograms, this plate is about 0.3 magnitude slower than the Cramer Instantaneous Isochromatic plate (Emulsion No. 12102). But inasmuch as some of its sensitiveness is gained by the extension in the red and greater speed in the green, it must be about 0.5 magnitude slower through the blue and yellow. It is about 0.6 magnitude faster by integrated light than the Wratten and Wainwright Panchromatic (Emulsion No. 4932). The grain of the plate is somewhat coarser than that of Eastman 40; it is about the same as that of C. I. I.

If the DuPont-Pathé Panchromatic emulsion should later appear on the market in plate form it will well merit test in various fields of photographic astronomical research.

## THE PHOTO-ELECTRIC PHOTOMETER OF THE DOMINION OBSERVATORY.

By F. Henroteau.

This photometer, which was constructed by E. Bouty in Paris, was obtained by the Dominion Observatory after the writer had investigated the equipments of pioneer research workers at Berlin and at Strasbourg.

It is composed of a quartz potassium photo-electric cell, the cathode of which is connected through a resistance of about five megohms to a source of negative potential, Edison alkali batteries, of approximately 240 volts. The anode of this cell is connected to a string electrometer hanging vertically below the metal casing which contains the cell. The wire of the electrometer moves in the electrostatic field of two vertical armatures, which can be more or less separated to vary the sensitivity and which are charged, respectively, through 5 megohm resistances, to +100 volts and —100 volts. As the wire collects an increasing negative charge coming from the photo-electric cell it moves toward the positive armature. A microscope focussed on the wire and on an illuminated scale serves to measure the rate of motion of this wire, which rate is directly proportional to the amount of light received by the cell. Normally the wire is grounded, and, by pressing on a switch held in the hand, the lead to earth is disconnected and readings of the moving wire are made. A chronograph is used to obtain the times at which the wire passes various divisions of the scale.

The photometer is at present employed in obtaining light curves of Cepheid variables and of stars of the β Canis Majoris type.

## ROTATION OF THE EARTH AND MAGNETOSTRICTION.

By Edward S. King.

E. W. Brown presented in 1926 evidence indicating changes, more or less abrupt, in the rate of the earth's rotation, which occurred about 1785, 1850, 1898, and 1918. He finds the observational data consistent with the hypothesis of an oscillatory change in the earth's mean radius.

The present study attempts to relate the earth's variable rotation with magnetostriction. Just as an iron bar changes its length when magnetized, the earth, under varying magnetic force may expand or contract. Of the measures of terrestrial magnetism, observations of magnetic declination are in general most reliable. Plottings of the secular change (+ to west) in declination for various places exhibit three striking features. A pronounced minimum occurs in the vicinity of 1900. A maximum is found near 1850 and later; and on many of the plots another maximum appears about 1920. These maximum and minimum points are remarkably near the dates found by Brown for changes in the length of the day. Some of these changes in terrestrial magnetism have been noted by Chree, but he gives no explanation.

Again, the correlation between the secular change in declination and the changes noted by Brown may be due to pressure effects arising from slight adjustments of the structure within the earth. The rearrangement of the strata, sufficient to produce the changes in the length of day, might also, by magnetostriction, affect the earth's magnetic conditions. We would then be dealing with results from a common cause.

## A METHOD OF ESTIMATING TIDAL FRICTION.

By Walter D. Lambert.

Mr. Lambert's paper recapitulated briefly the history of the problem of the apparent observed secular acceleration of the moon's mean motion and explained the reasons for thinking that the portion of the apparent acceleration not explained by the ordinary lunar theory is due to the very gradual slowing down of the earth's rotation by tidal friction, thus changing our time-keeping system and making the predictions of lunar theory appear to be at fault, whereas the real difficulty is elsewhere. The popular conception of the tidal friction as analogous to the rotation of a wheel checked by a brake band, the earth being the wheel and the ocean water the brake band, is quite erroneous.

The calculation involves simply the dissipation of energy and it is not always easy to form a mental picture of how the energy dissipated at a particular point contributes to the slowing down of the earth's rotation. For example, a friction-creating tidal current along a meridian dissipates energy that must be reckoned with but it appears in itself to exert no check on the earth's rotation.

The energy dissipated by tidal currents has been estimated by Taylor and Jeffreys (though the available data are rather uncertain) and found to be, for the mean lunar tides alone, about $1.1 \times 10^{19}$ ergs per sec. Almost all of this friction occurs in shallow seas, notably in Bering Sea, the deep oceans contributing surprisingly little.

The computations for a method of estimating tidal friction from an entirely different set of data were made by Heiskanen, though he did not at the time realize the significance of his result nor apply certain needed corrections. Heiskanen's work depends on the times and heights of high tide all over the world, that is, on the vertical component of the tidal motion, instead of on the horizontal component as in the work of Taylor and Jeffreys. The validity of Heiskanen's method may be proved by a method that makes it easier to visualize the forces at work than when the calculation is made by the dissipation of energy in friction-creating tidal currents.

The tides in the open sea are to a large extent conjectural, but using the best available information Heiskanen found a result which, when reinterpreted and approximately corrected, is $1.0 \times 10^{19}$ ergs per sec., that is, energy is being expended by the lunar tides at an average rate of about one and one-half (American) billion horsepower, and this energy comes out of the rotation energy of the earth. This figure sounds large when thus expressed, but even when the effect of the solar tides is included, it corresponds to a diminution in the length of the day of less than one one-thousandth of a second per century. Geologists say that in past geologic eras there were great areas of shallow seas and these would be favorable, as such, to large tidal friction and to a more rapid rate of change in the length of the day, with perhaps attendant geological consequences of interest. But shallow seas alone are not enough to produce tidal friction. There must be oceans alongside capable of producing large tides to sweep across the shallow seas and thus generate tidal friction and dissipate energy.

The close agreement of Heiskanen's corrected result with the result obtained by Taylor and Jeffreys is certainly accidental in view of the uncertainty of both sets of data, and all were justified in saying that the quantity obtained is about the quantity required to explain the excess of the observed secular acceleration over the acceleration computed by the lunar theory. This seems to imply that there is little friction in the elastic body tides of the earth, a belief for which there is some evidence to be found in a study of the variation of latitude.

## VARIABLE STARS IN THE ETA CARINAE REGION.

By Dean B. McLaughlin.

A study of the periods and apparent magnitudes of 46 Cepheids in the Eta Carinae star cloud reveals four different groups, each showing within itself a period-luminosity relation. Use of the Harvard photo-

graphic period-luminosity curve gives the parallaxes of the four strata of stars as:

| | |
|---|---|
| I | 0".00091 ± ".00005 |
| II | 0.00044 .00004 |
| III | 0.00021 .000005 |
| IV | 0.000067 .000004 |

Apparent magnitudes of long-period variables in this region indicate that some are probably foreground objects, while others are at the distances of the first two strata.

The distribution of the periods of the eclipsing variables in Carina is very nearly the same as that for the remainder of the sky. There are slightly fewer of the shorter periods in Carina, probably due to discovery effect, since short-period eclipsing stars average intrinsically fainter than those of longer period.

Upper limits of density have been calculated for 54 Carina eclipsing systems for which duration of eclipse is known. These show nearly the same distribution as similar limiting densities for stars in the remainder of the sky, except for a slightly greater frequency of the lower densities; again probably a discovery effect, dependent on luminosity.

Apparent magnitudes of the eclipsing stars, used with an assumed average absolute magnitude of —0.6, derived from stars for which spectrographic data are available, give parallaxes whose average is close to the average value determined from Cepheids. A density-luminosity relation for spectrographically observed stars is also used and gives parallaxes in substantial agreement with those from the Cepheids.

No Cepheids are found within one degree of the Eta Carinae nebula. This is interpreted as an obscuration effect. The nebula would then be at least as close to the solar system as the nearest stratum of Cepheids. Five eclipsing stars apparently occur within one degree of the nebula. Four of these are found to show evidence of low luminosity, and are therefore probably nearer than the nebula. These considerations indicate that Eta Carinae was of absolute magnitude —11 at maximum, and is now —3.

This paper is published in full in *The Astronomical Journal*.

## NOTE ON EMISSION LINES IN MIRA VARIABLES.

By Dean B. McLaughlin and Robert M. Petrie.

The great strength of H$\beta$ at the very bright maximum of Mira in August, 1928, suggested that all the Mira stars might fit into a correlation of the relative intensities of emission lines of hydrogen near light maximum with the brightness of the stars, *i.e.*, magnitude at minimum minus magnitude at date of observation, denoted $\Delta$M. The expected relation was a steady decrease of the ratios $\delta/\gamma$ and $\gamma/\beta$ with increasing $\Delta$M. Data for the study consist of estimates of emission line intensities on more than 100 spectrograms of 33 Mira stars, in conjunction with

magnitude estimates by the American Association of Variable Star Observers.

Intensity ratios plotted against $\Delta M$ without consideration of spectral class show very poor correlation. Separation into spectral classes at maximum reveals marked differences in the character of the correlation for the different classes. Only in class M5e for $\delta/\gamma$ and in M3e for $\gamma/\beta$ is a correlation of the expected kind found. In class M6e, $\delta/\gamma$ has a maximum value of about 4 when $\Delta M = 4.4$ and decreases nearly to unity for larger and smaller values of $\Delta M$. $\gamma/\beta$ shows similar behavior with a maximum value of about 25 when $\Delta M = 5.5$. In class M3e, $\delta/\gamma$ has a maximum of about unity when $\Delta M = 5$ and decreases slightly, but definitely for other values of $\Delta M$.

Considered purely as functions of spectral class, both ratios show marked increase from M2 to M7. For spectra of class M4 and earlier $\delta/\gamma < 1$, and from M5 to M7 $\delta/\gamma$ increases from about 1.5 to 4. This effect has been observed by Miss Cannon. The relation between the two ratios may be expressed by the formula:

$$\log \frac{\delta}{\gamma} = 0.4 \log \frac{\gamma}{\beta} - 0.3$$

The exceptional nature of $\chi$ Cygni, which, according to Merrill, shows some of the class-S characteristics, is evident from its very large departure from this relation.

A suggested explanation of the correlations of the ratios with $\Delta M$ takes account of two oppositely directed effects operating on the hydrogen lines. As range of light increases, excitation also increases, tending to produce greater intensity of the higher members of the Balmer series. If, as Merrill suggests, the titanium oxide absorption occurs at a higher level than the hydrogen emission, then increased $\Delta M$ would tend to strengthen the lower members of the Balmer series through decrease of absorption. If for smaller ranges of light the excitation effect operates most strongly, while for larger ranges the titanium oxide absorption decreases rapidly, then the rise and fall of the ratios of emission line intensities with increasing $\Delta M$ may be accounted for.

## SYSTEMATIC ERRORS OF PARALLAXES.

By S. A. Mitchell.

Schlesinger and van Maanen have utilized the spectroscopic parallaxes of Mt. Wilson for deriving the systematic errors of the longer series of trigonometric parallaxes. The differences, trigonometric *minus* spectroscopic, will represent the errors of the former only on the assumption that the latter are themselves without systematic errors. Since the spectroscopic parallaxes for stars of different spectral types must be reduced separately, this assumption requires: first, that the dif-

ferent spectral types are all on the same system, and second, that this system has no zero-point correction.

The spectroscopic parallaxes are indirect values which must be repeatedly calibrated by comparison with parallaxes directly determined. Trigonometric parallaxes, supplemented by what information is available from parallactic and peculiar motions, still remain the only practical basis of comparison. As more and more material is obtained by direct methods the spectroscopic parallaxes will become more thoroughly standardized.

The excellent parallaxes of Adams and his collaborators may be divided into three distinct classes: (1) Stars of later spectral types; (2) Stars of A and B types; and (3) Dwarfs. It is generally recognized that the spectroscopic parallaxes of the first of these classes have a higher accuracy than those of the other two classes.

In deriving the spectroscopic parallaxes, a correction of +".005 was used to reduce the parallaxes of all observers except van Maanen from relative to absolute. More recent work, particularly that of van de Kamp, has shown that the correction is +".003 in the Milky Way and +".008 at the pole of the Galaxy. Owing to the fact that the A and B stars are concentrated in the Milky Way, the reduction from relative to absolute will cause the spectroscopic parallaxes of F to M types to be too large by about +".0015, while the parallaxes of the A's and B's will be too large by +".0020. Added to these there will be corrections depending on the manner of drawing the curves for parallaxes of different spectral types.

Schlesinger's Catalogue may serve as an excellent means of deriving not only the systematic error of the spectroscopic parallaxes but also the errors of the trigonometric parallaxes as well. In forming the catalogue, Schlesinger applied corrections to the different trigonometric series to rid them of the major portions of their errors. The compilation of van Maanen in *Mt. Wilson Contributions* No. 357 gives the means of making the comparisons. In order to include more stars of A and B types than are in his publication, it was necessary to go to the original sources.

The values in the following table are formed from taking straight means of the differences trigonometric *minus* spectroscopic. The second column gives the correction to the Mt. Wilson spectroscopic parallaxes in order to reduce them to the system of Schlesinger's Catalogue. By using these values and applying them to the differences for each of the trigonometric series (W = Mt. Wilson, A = Allegheny, etc.) we have the values in the following columns. They represent the corrections to the trigonometric parallaxes. The stars of A and B types were treated separately but only their combined values are here given. The first number in each case gives the correction in units of 0".0001, while the second is the number of the stars.

CORRECTIONS TO PARALLAXES.

| Types | Spectroscopic | W | A | M | Y | S |
|---|---|---|---|---|---|---|
| All Stars | —22 1650 | —35 179 | +13 496 | + 1 593 | + 1 190 | —57 128 |
| Late types | —12 950 | —31 132 | +14 312 | + 1 313 | + 8 83 | —55 77 |
| A & B types | —41 273 | +72 8 | +13 87 | + 3 125 | —44 31 | —28 22 |
| Dwarfs | —41 405 | —39 28 | +39 84 | +16 163 | —19 72 | —34 36 |
| Schlesinger | | —43 | + 8 | — 4 | — 6 | —35 |
| van Rhijn | | —32 | +13 | — 2 | —25 | —58 |
| Strömberg | | —30 | +26 | + 3 | +34 | |

The second half of the table gives the systematic corrections to the trigonometric parallaxes by other authorities. In *G. P.* No. 37 van Rhijn finds the correction —".0035 to the Mt. Wilson spectroscopic parallaxes. His corrections to the different trigonometric series are altered by ".0013 to reduce them to the system of the Schlesinger Catalogue.

It is seen from the above Table: (1) that the late-type stars have the small correction of —".0012, which is just the amount of the erroneous reduction from relative to absolute, (2) that the early-type stars are consistent among themselves but they have a larger correction, and (3) that the dwarfs have larger accidental errors that make them unsuited as a test of errors either spectroscopic or trigonometric.

It seems desirable that the Mt. Wilson spectroscopic parallaxes be again reduced so as to calibrate them against the greater wealth of parallax material now available.

## THE RELATION BETWEEN THE DEGREE OF ANOMALOUS DISPERSION AND LINE INTENSITY.

BY CHARLOTTE E. MOORE.

The degrees of anomalous dispersion estimated by A. S. King for 47 Cr lines, 102 Ti lines and 72 Fe lines, when compared with his estimates of arc and furnace intensities of these lines, indicate a direct correlation between line intensity and index of refraction. His estimated "degree of anomalous dispersion" refers to a deflection of a ray. Assuming that it varies as a product of the index of refraction less unity and a density gradient, the average low temperature furnace intensities shown by the three elements for each observed "degree of anomalous dispersion" should be in the inverse order of the ease of vaporizing these elements, employing J. Q. Stewart's theory of the connection between refractivity and line-width in absorption. The melting points of these three elements are 1535° C for Fe, 1615° for Cr, and 1800° for Ti. The average intensity of the lines in the low temperature furnace is highest for Fe and lowest for Ti, where the averages include the largest number of lines. Hence there is a qualitative agreement with the theory.

On the basis of the present data, no explanation can be made of the variation in slope of the lines representing the points obtained by plotting the logarithm of the observed "degree of anomalous dispersion" against the theoretical intensities for each of 14 multiplets. The observed deflections vary as some power of the theoretical intensities but the power varies for multiplets involving the same low energy level in the atom. In Ti, which offers the best material for multiplet investigation, these slopes range from 0.38 to 0.93. They do not vary according to the higher energy level involved in the transitions and neither do they seem to be connected with the possible paths of the electrons back to the normal state. For example, the slopes of the lines representing the plotted intensities of two Ti multiplets are 0.44 and 0.79 and the corresponding multiplet designations are $a^3F'$—$b^3F$ and $a^3F'$—$c^3F$, respectively. In this case the terms $b^3F$ and $c^3F$ are roughly only 1700 frequency units apart and yet the range in slope is 0.35. Measures of these observed deflections are necessary in order to provide adequate material for a theoretical investigation.

## TEXAS FIREBALL OF AUGUST 8, 1928.

By C. P. Olivier and O. E. Monnig.

A brilliant fireball appeared at 9:28:24 C.S.T., on August 8, 1928, somewhat southwest of Fort Worth, Texas. Observations were made by members of the A.M.S. and others. All were collected by O. E. Monnig, and preliminary calculations made by him. Definitive results are that the object left a persistent train from about 106 to 75 km altitude. The fireball itself disappeared at the latter altitude. The actual point of appearance was much higher than 106 km. It fell at an angle of 57° with the horizon, moving towards azimuth 192°±. Its orbit had an inclination of 130°+. While the radiant was not determined with accuracy, due to the case being a very difficult one to compute, the fireball was not a Perseid.

*(To be continued.)*

---

## SCORPIO.

On summer's south horizon, he
Crawls in bright, baleful majesty:
Antares is his old red heart.
He slew Orion with his sting
And since he did that horrid thing
They circle heaven far apart.

1490 Stuart St., Denver, Colorado. Lilian White Spencer.

## TEXAS FIREBALL OF AUGUST 8, 1928.

By CHARLES P. OLIVIER and O. E. MONNIG.

A very brilliant fireball that appeared at 9:28:24, C.S.T., over central Texas, on August 8, was observed by three members of the American Meteor Society, namely S. Bunch and O. E. Monnig at Ft. Worth and J. H. Logan at Dallas. The object appearing early in the summer evening when many people must have seen it, and being of unusual brightness, Monnig decided to make special efforts to secure observations from as many places as possible. In this he was aided by several newspapers, and as a result of this campaign he received 16 replies, 8 of which are of value in determining the heights of the object. Monnig, himself, using the method explained in Chapter 14 of "Meteors" derived the end height by combining the Ft. Worth, Dallas, and Hamilton observations, two at a time. As the results did not agree as well as he expected, he turned over all the material to the headquarters of the A.M.S., and the final reductions were made by C. P. Olivier, assisted in the least squares solutions by Dr. S. G. Barton. However, Monnig's solution for one end served as a most useful check, he has personally written part of this paper, and to his energy is due the collection of the data and the very possibility of publishing these results. The paper is therefore properly signed by us both.

To arrive at the results given three solutions were made. First a preliminary graphical, then one combining the (presumably) best observations two by two, finally a least squares solution. The case was difficult, though the reason was not at first apparent. It happened that 5 of the 8 rather reliable observations were made from stations pretty nearly in the plane of the meteor's motion, hence it appeared almost vertical from these five, though we find it actually came down at an angle of 57° to the horizontal. The next great difficulty was that many of the observations refer evidently to the coördinates of the ends of the beautiful train left, and especially did not refer to the actual beginning point of the object itself, though its end point probably coincided nearly with the end of the train. Due principally to these causes, the writers have been forced to exercise personal judgment in handling the results; no exact rule could be followed. Strange to say also, contrary to our experience, the azimuths were better observed than the altitudes. Having then excluded two impossible azimuths, it was found that 6 were available for the beginning and 8 for the end point. The following table gives the observers, stations, coördinates of beginning and end points observed, assigned weights, and other data. Those data not used in the solutions are bracketed.

Remarks are now necessary to explain the procedure. Bunch and Monnig were outdoors adjusting a star camera. Unfortunately they

TABLE I.

| No. | Station | Long. | Lat. | Duration | Color | Beginning | | End | | Weight in Solution | Magnitude |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Ft. Worth | 97° 21.2 | +32° 47.9 | 0.5* | White | 51.5 | 22.2 | 28.4 | 16.6 | 10 | lightning flash |
| | | | | 0.8* | Orange | — 3° 30′ | 258.5 | —26° 50′ | 255° 45′ | | |
| 2 | Dallas | 96 48.3 | 32 48.4 | 4.0 | Magnesium Flare | 36.4 | 41.2 | 35.6 | 36.6 | 10 | 4 × Jup. |
| | | | | | | —10° 50′ | 240.0 | —22.0 | 237° 15′ | | |
| 3 | Hamilton | 98 07.8 | 31 42. | 3.0 | White | 70.9 | 246.7 | 69.7 | 315.7 | 5 | 1-3 × Jup. |
| | | | | | | +37° 20′ | 293.5 | +16° 20′ | 286.0 | | |
| 4 | Breckenridge | 98 54. | 32 47. | | Fire | [30° | 215°] | [30° | 45°] | | = an orange |
| 5 | Albany | 99 07. | 32 43. | 1.0 | | 70° | 300° | [35°] | 315° | 2 | sun-like |
| 6 | Turnersville | | | | | | | | | | |
| 7 | Smiley | 97 36. | 29 14. | 10.0 | Incandescent | 40° | 176° | 15° | 173.5 | 2 | |
| 8 | Temple | | | | | E | | W | | | v. bt. light |
| 9 | Smithfield | 97 12.7 | 32 52.3 | 1.0 | | 38° | 15° | 22° | 17° | 2 | |
| 10 | Gatesville | 97 44 | 31 25 | 8-10 | Bright | [82° | 225°] | [20°-26°] | 157½° | 2 | ⅓ Moon |
| 11 | Cleburne | | | 30 | Fiery Blue | SW | | | | | |
| 12 | Burleson | 97 17 | 32 33 | 0.8 | Blue-White | [85° | 125°] | 35° | 13° | 2 | |
| 13 | Oklahoma City | | | | Bril. White | low SW | | | | | |
| 1 | Ft. Worth | | | | Nickel-color | | | | | | |
| 3 | Hamilton | | | 3.5 | Yellow-Green | | | | | | >Moon |
| | Brownwood | | | | Star | S of E | | | | | v. bright |

TABLE I—*Continued.*

| No. | Station | Remarks | Observer |
|---|---|---|---|
| 1 | Ft. Worth | Train 20° long, reddish, 5.0 sec. | S. Bunch |
| | | Train 6.0 sec. | O. E. Monnig |
| 2 | Dallas | Train yellow-red, 10.0 sec. Burst. | J. H. Logan |
| 3 | Hamilton | Light >Full Moon (others' estimate) | |
| | | Train, yellowish, 2.0 min. | J. T. Chesley |
| 4 | Breckenridge | ∴ = 10′ ?? | Mrs. Mary French |
| 5 | Albany | Train, yellowish, 0.5± min. | J. A. Clarke |
| 6 | Turnersville | Light = auto light; awakened by noise. | Mrs. S. Y. Meharg |
| 7 | Smiley | Train, 5.0 sec. Burst. | Dr. A. B. Currie |
| 8 | Temple | Train 1 or 2 min. | E. M. Deal |
| 9 | Smithfield | | W. D. Quinn |
| 10 | Gatesville | Train, very bright, 10 to 15 min. | G. W. Byrom |
| 11 | Cleburne | Train, red 2 min. Burst. | W. Garrett |
| 12 | Burleson | Light = charge flash-light powder. | R. Brown |
| 13 | Oklahoma City | | Miss E. Kendall |
| 1 | Ft. Worth | Red train; Burst. | A. Stedman |
| 3 | Hamilton | Train golden, 1.0 to 1.5 min. | Miss L. Cameron |
| | Brownwood | Burned out, no explosion. | O. C. Pauns |

were looking down, hence did not see the beginning. The positions for Station 1 are their combined results. Logan was at his telescope and also missed the beginning. Chesley, who has since joined the A.M.S. and knows the constellations, was looking at the sky but wrote down his observations from memory some days after. Dr. Currie, at No. 7, did not see the object but sent excellent information collected from several persons. Quinn, at No. 9, used instruments (later) to determine the coördinates. The estimates at Nos. 5, 10, and 12 were estimations from memory, though Brown, at No. 12, made his from the same spot at night. But the data on the whole are good and permit a solution for heights in which we may have confidence. Obviously, however, the coördinates at Nos. 1 and 2, derived by trained observers who immediately recorded their results, deserve exceptionally high weight.

A solution by least squares of the most probable position on the Earth's surface above which was the upper end of the train gave the following results based on 6 azimuths:

$$\text{long.} = 97^\circ\ 46'.7\ \text{W},\ \text{lat.} = +31^\circ\ 52'.0$$

A similar solution, based on 8 azimuths, gave for end point of train:

$$\text{long.} = 97^\circ\ 54'.5\ \text{W},\ \text{lat.} = +31^\circ\ 39'.5$$

The method for forming the separate equations used may be found in Bauschinger's *Bahnbestimmung*, pages 593 to 597. The original paper from which this is taken was by J. G. Galle in *Astr. Nach.*, Nr. 1989-1990. However, the result for end point, using observations at No. 1 and No. 2 combined according to our usual method for two stations was

$$\text{long.} = 97^\circ\ 44'.4\ \text{W},\ \text{lat.} = +31^\circ\ 43'.4$$

As these results differ more than was to be expected, and No. 1 and No. 2 were manned by 3 trained observers as stated, the adopted coördinates of the end point are the means of the two above values, or

$$\text{long.} = 97^\circ\ 49'.4\ \text{W},\ \text{lat.} = +31^\circ\ 41'.4$$

Heights were then derived by using the equation

$$z = 2\rho \sin \frac{s}{2} \frac{\sin (H + s/2)}{\cos (H + s)}$$

It was evident that for the beginning point the observations of Nos. 2, 3, and 9 referred to the upper end of the dense train and were in good agreement. The mean of these three gives 105.7 km which was assumed correct. The very good observation of No. 1, which gives 143.6 km, evidently refers to a point higher up the path. As the path was nearly vertical as seen from No. 1, the azimuth would not be greatly affected by this assumption. The plot shows the azimuth line from No. 1 slightly to the west of the adopted point, which fits in with this hypothesis. The unreasonably great values given by altitudes from Nos. 5, 7, and 10 are mostly due to the usual errors of estimating high altitudes by persons not in practice; they nearly always overestimate.

TABLE II.

| Station | Beginning Pt. | Ending Pt. |
|---|---|---|
| 1 | 143.6km | 72.8km |
| 2 | 105.5 | 79.9 |
| 3 | 112.2 | 79.8 |
| 5 | 472.8 | 121.3 |
| 7 | 263.2 | 80.3 |
| 9 | 99.3 | 60.2 |
| 10 | 378.7 | 15.6 |
| 12 | ..... | 77.2 |

The 8 heights for end point show 6 in agreement, 2 far out. The inclusion of the 2, as it happens, would scarcely change the mean, but as they are obviously erroneous only the 6 quite accordant values are

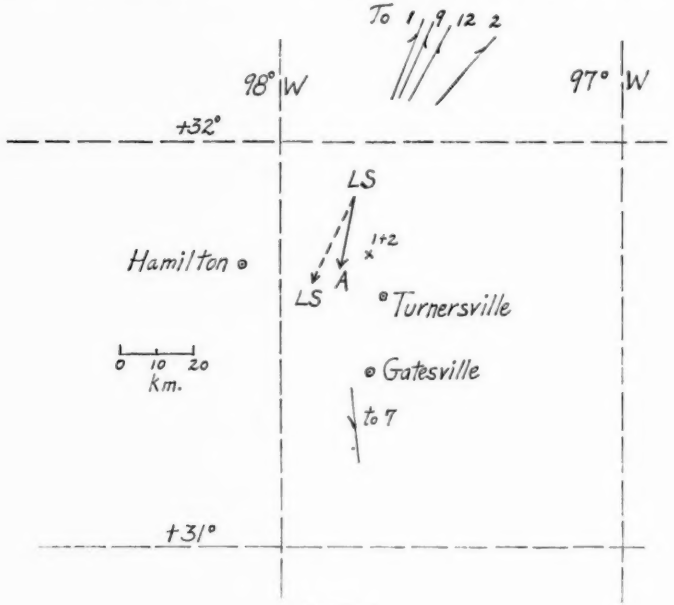



FIGURE 1.

used, giving 75.0 km. Calculation gives the projected length of the dense train as 20.0 km, with $105.7 - 75.0 = 30.7$ km as its height. Its length was therefore 36.6 km. It is very interesting to note that these limits fit in well with those for dense meteor trains, as given in "Meteors," p. 149. The angle to the horizon then comes out 56° 55′ and the azimuth of plane of motion 12° 15′. The radiant is at $h = 56° 55'$, $a = 192° 15'$, uncorrected for zenith attraction. Due to causes enumerated, the estimates of duration may refer to different angular (and true) distances traversed by the body. So the zenith attraction

was assumed to be 1°, and the velocity parabolic. Neither assumption is true but they fit the conditions approximately. The corrected radiant then is as given under A. If one prefers the solution by least squares directly, without the combining done as stated, the radiant will be as under B.

| A | | B | |
|---|---|---|---|
| h = 54° 55′, | a = 192° 15′ | h = 47° 48′, | a = 208° 00′ |
| $\delta$ = +64° 18′, | $\alpha$ = 287° 34′ | $\delta$ = +68° 51′, | $\alpha$ = 306° 47′ |
| $\beta$ = +82° 23′, | $\lambda$ = 351° 02′ | $\beta$ = +76° 05′, | $\lambda$ = 26° 08′ |

Parabolic orbits calculated as usual then give for A and B, as radiant:

| | A | B |
|---|---|---|
| 1928 Aug. 9.13 G.C.T. | | |
| i = | 130° | 139° |
| $\Omega$ = | 136 | 136 |
| $\pi$ = | 327 | 21 |
| q = | 1.0 | 0.7 |

The results for A and B diverge considerably, but, as said, in our opinion, A represents the truth better.

As a final check the radiant was calculated by finding the intersection of the two paths as plotted at No. 1 and No. 2. The result, $\alpha = 18°$, $\delta = +15°$, is so different from those in solutions A or B as to be most surprising at first glance. However, the reason is that the plotted paths were so nearly parallel as seen from No. 1 and No. 2, that the slightest error in plotting made a very wide difference in the intersection point. On the whole this is far the most difficult case ever handled by the writers, many circumstances combining to make the solution almost indeterminate in some respects, as that just above. Despite this, we may, it is believed, have confidence at least in the heights and the fact that the object moved with retrograde motion at a rather high angle. Equally good data would usually give far more certain results as to the orbit.

The table of data shows the usual divergences in minor details. Differences in estimates of brightness can be partially accounted for by the fact that some observers refer to the illuminating flash made by the meteor, while others refer to the body of the meteor itself. Similarly, some estimate the duration of only that part of the meteor's course which they actually saw (*e.g.*, those at No. 1), while others apparently try to allow for the flash plus their reaction time (No. 2 did this). The writers conclude from inspection that the color was about that of a magnesium light or blue-white, and that the main train lasted at least 6 seconds. The train changed shape and was reddish-yellow in color. The actual head of the meteor was scarcely seen by many observers. The meteor probably belonged to a certain class, of which Olivier has seen many examples, that leave fine trains but have heads relatively inconspicuous. The estimates of time are almost useless due to the fact that different people refer to different beginning points, and some certainly mix up the duration of the train with that of the meteor itself.

No intelligent conclusion as to the velocity can therefore be drawn, in the writers' opinions.

As the train was a most interesting one, we give notes on it from the original records. No. 1, Bunch: "The train gradually became crooked as it faded and gave the impression of ashes filtering down through the atmosphere." No. 2, Logan: . . . "the trail was at first solid, but soon broke up into a train of sparks. . . and kept to the curved trail that the meteor itself had made . . "

A most interesting feature, reported only from Hamilton, No. 3, was a smoke or gas ring which became visible at the point where the meteor ended, and was first noticed by Chesley after the train had faded from view. It was visible to the naked eye, but as Chesley had field glasses in his hands he was able to use them in watching its expansion. He estimates its total duration as two minutes, during which time its diameter increased from ½° to 4° or 5°. Miss Cameron, at the same station, estimates the duration as 90 seconds, and the increase in diameter from 2° to 5°. She adds: "The meteor seemed at its brightest where the ring of smoke was seen." Adopting an expansion of ½° to 5°, and using a weighted mean of the time estimates, combined with the actual distance of these observers from the lower end of the dense train (80.3 km), where the ring is assumed to have formed, it follows that the ring had a radius of .35 km when first seen; that it expanded to a radius of 3.5 km; and that the particles of which it was composed were moving outwards along each radius at a velocity of the order of 120 km per hour. No change in position of center of ring was noted by Chesley.

No. 9, Quinn, was positive about the lack of a definite "head." Sent in four drawings and excellent descriptions of train. The preceding part was, however, excessively bright and elongated, divided in following part by a darker region. The train was not so bright behind this elongated part.

No. 7, Dr. Currie: ". . . left a luminous trail behind for several seconds . . . was very pronounced . . . and seemingly brightened the star-lit night . . " No. 12, R. Brown: ". . . doubled in the shape of a U with the mouth turned east." All necessary notes by the other observers are contained in the table.

The sound of an explosion was reported from the station nearest the meteor's end point (No. 6); unless this was a shock wave, we have a definite example of a detonating meteor which ended higher than most of its class: Denning, in *Observatory*, **49**, 1926, p. 314-315, concludes that "the sound limit or level for audible detonation seems to lie about 34 miles." The bursting reported by several observers, and the formation of the ring, tend to confirm an actual explosion, though not necessarily an audible one. Two other observers insist that they heard certain sound phenomena simultaneously with the appearance of the

meteor. The writers in time past have been inclined to think reports of this nature were due to suggestion, because obviously no sound wave could arrive simultaneously with the light. But merely because one does not have a good explanation to offer, is no reason for denying that a certain phenomenon took place. Logan in particular, at No. 2, who has had considerable experience in astronomical work, says he heard a distinct and long drawn out "pop" just as the object appeared. Mrs. French at No. 4 says: "There was a hissing or popping as the meteor appeared . . . it was accompanied by a hissing or whirring noise." Similar reports have been published about other fireballs; very recently one in Texas that was worked up by E. H. Sellards of the University of Texas, who felt obliged to accept the statements as true.

With this evidence, added to the undeniable fact that a somewhat similar popping accompanies the aurora in northern regions at certain times, a new problem is offered to the physicist or meteorologist for solution. An electrical origin might be guessed at.

The writers desire to express to all the persons who aided us so effectually in collecting and sending in the data our most hearty thanks. Without such help it would be impossible to calculate the heights of meteors and those who assist give real aid to science. More and more such observations are reported yearly, but most have no duplicates. All interested in astronomy are urged, when they see a brilliant meteor, at once to write down the necessary observations of its path and report them. The A.M.S. will try to see that all possible cases are worked up and published. Mr. O. E. Monnig, 312 W. Lenda Street, Ft. Worth, Texas, is officially charged with collecting such reports in Texas and the bordering states, on behalf of the A.M.S. Reports from these states sent to him directly will be forwarded to headquarters for reduction and publication.

1929 JANUARY 26.

## THE ORBIT OF THE UNDISCOVERED SATELLITE *U*.

By WILLIAM H. PICKERING.

A recent publication by the Astronomer Royal of England in the *Monthly Notices*, 1929, **89**, 260, has directed my attention to certain data regarding this satellite to which I did not previously have access. Reference is here made to the constantly shifting geocentric latitude of the planet Saturn. In Table I are given the year, the heliocentric longitude, and the deviations in latitude, the first and last being taken from the *Monthly Notices*. These results are plotted in Figure 1, with the heliocentric longitudes counted from right to left at the top, the years at the bottom, and the latitudes at the left. It will be seen that the re-

sults follow in general a sinusoid with an amplitude of 0″.65 and a period of 480°. This implies an inclination of the orbit of *U* to the ecliptic of 50°, and a retrograde revolution of the nodes in 38.4 years. The inclination, which doubtless is constantly changing, is at present even higher than that of the orbit of the retrograde eighth satellite of Jupiter, which until recently was 34°. Satellite *U* is now near its node, and slightly to the south of the orbit of Saturn. This proximity should aid materially in finding it this year. The rapidity of the revolution of

TABLE I.

THE PERTURBATIONS OF SATURN IN LATITUDE.

| Date | H.L. | Δ Lat. | Date | H.L. | Δ Lat. |
|---|---|---|---|---|---|
| 1901.6 | 285° | +0″.1 | 1916.0 | 103° | —0″.0 |
| 02.6 | 296 | + .1 | 17.1 | 117 | — .9 |
| 03.7 | 308 | + .3 | 18.2 | 132 | — .5 |
| 04.7 | 319 | + .2 | 19.3 | 146 | — .7 |
| 05.8 | 330 | .0 | 20.3 | 159 | — .1 |
| 06.7 | 342 | + .4 | 21.4 | 173 | — .5 |
| 07.8 | 354 | + .3 | 22.4 | 186 | — .4 |
| 08.8 | 6 | — .3 | 23.4 | 198 | — .6 |
| 09.9 | 21 | .0 | 24.4 | 210 | — .5 |
| 10.9 | 34 | — .1 | 25.4 | 222 | — .1 |
| 11.9 | 48 | — .4 | 26.5 | 334 | — .6 |
| 12.9 | 61 | — .1 | 27.5 | 245 | .0 |
| 14.0 | 76 | — .4 | 28.5 | 258 | + .1 |
| 15.0 | 89 | — .3 | | | |

the nodes, 130° to each revolution of the satellite, is phenomenal, although, if considered angularly, it is only half as rapid as that of the nodes of the orbit of the Moon. The question may now naturally be asked what effect will this high inclination of the orbit have on our previous conception, based on an orbit of slight inclination, like that of Phoebe? Obviously it will make no difference in the period, or mean distance of the satellite, but will reduce the maximum mean distance in longitude to 0.64 of its former computed amount. Since the attraction of the Sun lengthens the periods of all the satellites, for a satellite so remote from its primary as *U*, it is possible that the effect may be appreciable, even if small. This would further reduce its apparent distance in longitude from its primary.

An attempt was next made to determine the eccentricity of the orbit, and the longitude of its perisaturnium. Owing to the unknown rate of revolution of the apsides, which is presumably considerable, it was thought best to confine our attention only to the last two revolutions of the satellite. This would include therefore only the observations of the last twenty-eight years. The interval between longitude 263° in 1899.7 and longitude 244° in 1927.4 was divided into eight equal parts. The mean deviations in these eight parts were found to be —0″.02, +0″.03, +0″.40, +0″.25, +0″.03, +0″.10, +0″.20, and +0″.22. (See "The Orbit of Saturn," Table III, POPULAR ASTRONOMY, 1929, **37**, 213.) Allowing for the error in Hill's rate of revolution of the planet, amount-

ing to 0″.26 during the whole period, all of the mean deviations, save the third and fourth, were found to lie very closely along a horizontal line, indicating a nearly circular orbit! The average deviation of the six satisfactory means was found to be ±0″.03. The two discordant ones were too exceptional to indicate anything except accidental errors, in one case amounting to +0″.36, and in the other to +0″.18. Our final conclusion is that the evidence appears to indicate that the eccentricity of the orbit has of late been rather small. This should further aid us in finding the satellite. Should the eccentricity ever exceed 0.6 when both the aposaturnium and node lay in the direction of the Sun, or opposite to it, Saturn would be in imminent danger of losing the satellite, and it would then become an independent planet, related to Saturn much as planet *O* is believed to be related to Neptune.

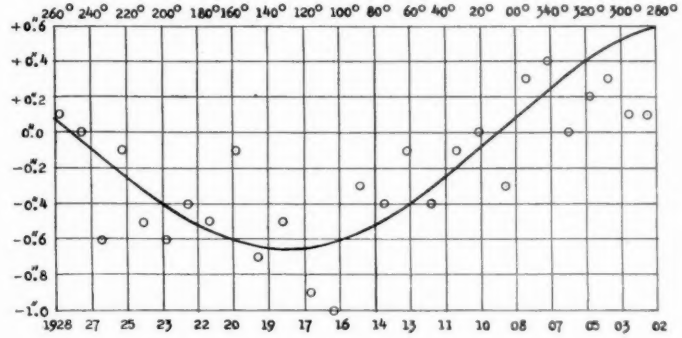



FIGURE 1.

RECENT PERTURBATIONS OF SATURN IN DECLINATION.

The ratio of the sidereal period of Phoebe to that of its primary is 20.5, that of our Moon 13.4, that of the outer satellite of Jupiter 5.8, and that of *U* 2.1. With regard to the brightness of the latter, the magnitude of Phoebe is given as 14.5, and after a careful examination of some plates kindly sent me by Dr. Adams, I conclude that *U* can hardly be brighter than magnitude 13. Phoebe for some reason was not found upon the plates, although a provisional search was made in the area where it should have been, according to the *American Ephemeris*. I understand that it still coincides closely with its computed position. The plates were supposed to show stars of the 17th magnitude, so I am at a loss to account for the discrepancy. The inner satellites of Saturn are of very low density, that of Mimas in terms of water being given as 0.4. When we get out to Titan we find that the density has risen to 3.5. From its faintness we conclude that *U* is exceptionally dense, and consists perhaps simply of a black iron ball. This at once suggests that the other faint outer satellites may also be denser, darker, and much more massive than has previously been supposed.

Assuming that the asteroids are simply comets that have lost their luminous gas, and have been captured by Jupiter, as was proposed many years ago, and that their more nearly circular orbits are due to the resistance caused by our subsequent passage through one or more nebulae, it might also be suggested that $U$ was merely another cometary capture. The objection to this view, however, consists in the great mass of $U$, nearly one-third that of Titan, and more than one-half that of our own moon. No asteroid will compare with it in this respect. It seems to be more nearly related in origin to planet $O$, whose mass is believed to be about two-thirds that of the Earth.

Assuming these and my earlier computations to be correct, the satellite will be in conjunction in longitude with Saturn when the latter reaches heliocentric longitude 305° in 1933. The planet will be in opposition this year on June 19, and the satellite should then be 59′.4 to the east of it, and 21′.6 to the south in heliocentric longitude and latitude. Correcting these figures to right ascension and declination, the satellite should lie 4.26 minutes to the east of Saturn and 31′.0 to the south of it. Its motion in its orbit is westerly and southerly at the rate of 4″.5 per day in both directions. The ascending node for Saturn in 1928 is 251°. This node, which refers to the inclination, must not be confused with the node of the sinusoid given in the previous paper, since it has nothing whatever to do with it. These figures, of course, cannot be taken as exact, on account of the minuteness of the perturbations of Saturn, on which they are based, but they should give a general idea where to look for the satellite, and it is hoped that by their aid some observer will succeed in finding it this year.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., MARCH 30, 1929.

## NEBULOSITIES NEAR THE GALACTIC POLE.

J. G. HAGEN, S. J.

A good opportunity of seeing what W. Herschel called "Extensive Nebulosities" will present itself during May and June.

The two stars 30 and 31 Comae are the nearest naked-eye stars to the Galactic Pole. The star 31 Comae has a reddish tint and is of magn. 5.0. It will be found in the position

$$12^h\ 48^m.0,\ +27°\ 57'\ (1925.0)$$

The other star, 30 Comae, is of magn. 6.2 and precedes 31 on the parallel 2.4 minutes of time.

Now the space between the two stars is filled with what appear to be nebular clouds of the highest density V (on our scale of five).

In recognizing the clouds the observer will be aided by several advantages. First, no matter how transparent the terrestrial atmosphere

may be, he cannot possibly see a clear space between the two stars. Then, there are no star-chains around, which have been thought to cause illusions; the region is very poor in stars and no deceptive contrast is to be feared on that side; there is no Zodiacal Light near that might cause obscurity. To one who is not color-blind the cloud will appear yellowish gray.

But there is also a difficulty. As far as the observer can sweep with his instrument he will not reach the limit of the cloud, as the Galactic Pole appears densely covered with nebular matter within a circle of at least twelve degrees in diameter. Heis and Newcomb reckoned the position of the Pole 1½ degrees south preceding the two stars.

Pointing his telescope, the same evening, to some regions of the Milky Way the observer cannot fail to notice the difference in the celestial backgrounds.

Specola Vaticana, 1929 April 11.

## PLANET NOTES FOR JUNE.

By CLIFFORD E. SMITH.

The *Sun* during June will be moving from the central part of Taurus to the western part of Gemini. On June 21 the sun will pass through the summer solstice, which marks the beginning of summer. This will occur late in the day, Greenwich Civil Time. The position of the sun on June 1 and June 30 will be, respectively: R.A. $4^h\ 33^m$, Decl. $+21°\ 58'$; and R.A. $6^h\ 34^m$, Decl. $+23°\ 14'$.

The phases of the *Moon* will occur as follows:

| | | |
|---|---|---|
| New Moon | June 7 at 8 A.M. | C.S.T. |
| First Quarter | 13 " 11 P.M. | " |
| Full Moon | 21 " 10 P.M. | " |
| Last Quarter | 29 " 10 P.M. | " |

The moon will be at perigee (nearest the earth) on June 8, and at apogee (farthest from the earth) on June 22.

*Mercury* will be in the eastern part of Taurus. Its apparent motion will be slowly retrograde until June 21. On June 9 Mercury will be at inferior conjunction, and thus its apparent position will be near that of the sun, but by the end of the month it will rise about an hour and a half before the sun.

*Venus* will be in Aries. Its apparent motion will be direct, and it will move from the western to the eastern part of the constellation. On June 4 Venus will be in conjunction with the moon, and at that time it will be distant from the moon only a few minutes of arc. On June 29 Venus will be at greatest elongation west. During the latter part of the month it will rise about three hours before the sun.

*Mars* will be in the constellation Leo, and at the end of the month it will be about two degrees from the bright star Regulus. Its apparent motion among the stars will be direct (easterly). On June 11 Mars will be in conjunction with the moon. During the middle of the month it will set about four hours after the sun.

*Jupiter* will be in Taurus a few degrees somewhat south of the Pleiades. The

apparent motion of Jupiter will be direct, and during the middle of the month it will rise about an hour and a half before the sun.

*Saturn* will be in the western part of Sagittarius. Its apparent motion during the month will be retrograde. On June 19 it will be in opposition with the sun, and thus during the latter part of the month it will be near the meridian at midnight.

*Uranus* will be in central Pisces. Its apparent motion will be direct. It will be in conjunction with the moon on June 2, and again on June 30. During the latter part of the month Uranus will rise about midnight since early in July it will be at quadrature west of the sun.

*Neptune* will be in Leo about a degree from the bright star Regulus. During the middle of the month it will set about four and a half hours after the sun. Its apparent motion will be direct. It will be recalled that Mars also will be near Regulus during the latter part of the month.

---

**Venus and the Moon.**—A very close conjunction of Venus and the Moon will take place early in the morning of June 4. In the eastern West Indies and further east in the Atlantic the moon will occult Venus. The occultation will occur at about six o'clock (Eastern Time).

WM. C. DOYLE.

Creighton University Observatory, Omaha, Nebraska.

---

## Occultations Visible at Washington.

[From the *American Ephemeris.*]

| Date 1929 | Star's Name | Magnitude | IMMERSION Washington C.T. | IMMERSION Angle from N | EMERSION Washington C.T. | EMERSION Angle from N | Duration |
|---|---|---|---|---|---|---|---|
| | | | h m | ° | h m | ° | h m |
| June 1 | 336 B. Aquarii | 6.3 | 1 59 | 39 | 3 2 | 268 | 1 2 |
| 5 | $\sigma$ Arietis | 5.4 | 3 37 | 7 | 4 5 | 300 | 0 28 |
| 18 | 150 B. Librae | 6.1 | 22 22 | 95 | 23 45 | 316 | 1 24 |
| 21 | 36 Ophi. (1st star) | 5.4 | 0 45 | 181 | 0 58 | 197 | 0 13 |
| 23 | $\tau$ Sagittarii | 3.5 | 3 31 | 148 | 3 56 | 185 | 0 25 |
| 24 | $\omega$ Sagittarii | 4.8 | 0 11 | 68 | 1 43 | 271 | 1 32 |
| 24 | $A$ Sagittarii | 4.9 | 2 25 | 79 | 3 53 | 244 | 1 27 |
| 28 | 290 B. Aqua. ii | 6.3 | 2 3 | 28 | 3 13 | 267 | 1 11 |

---

## Prediction of Occultations for Amherst, Mass., and Vicinity.

Observations of occultations of stars by the moon may be done by amateurs with a degree of accuracy which makes such observations very valuable for the work of revision of the tables of the moon, and such a program of observation would be very well worth an amateur's time.

The present set of predictions is given for a region surrounding Amherst, Massachusetts, the area assigned to the computer by Professor Ernest W. Brown, of Yale University, who is in charge of the work for this hemisphere. If a sufficient number of observers in some other part of the United States or Canada will express a wish for predictions over an area which will include them, and will communicate with the writer, arrangements will be made for furnishing the necessary predictions. The results of observations should be sent directly to Professor Brown, at New Haven, Connecticut.

These predictions are computed by a SHORT SEMI-GRAPHICAL METHOD devised by Dr. L. J. Comrie, of H. M. Nautical Almanac Office, London, and all materials including the "Elements of Occultations" have been furnished by that office,

through the courtesy and generosity of the *Computing Section of the British Astronomical Association*, to whom the computer acknowledges his indebtedness. Miss Grace Edwards assisted materially with the preliminary computation, and to her also the computer acknowledges his thanks.

The predictions for Amherst will appear month by month in these pages.

TABLE OF PREDICTIONS.
(Disappearances Only)

| Diagram | Date 1929 | Star | Mag. | G.C.T. h m | a m | b m | P ° |
|---|---|---|---|---|---|---|---|
| A | June 1 | 336 B. Aquarii | 6.3 | 7 19 | —0.7 | +2.2 | 35 |
| B | 19 | 150 B. Librae | 6.1 | 3 38 | —2.1 | —0.5 | 86 |
| C | 21 | 36 Ophiuchi (1st star) | 5.4 | 5 46 | ... | ... | 167 |
| D | 23 | $\tau$ Sagittarii | 3.5 | 8 39 | ... | ... | 148 |
| E | 24 | $\omega$ Sagittarii | 4.8 | 5 32 | —2.1 | +1.0 | 65 |
| F | 24 | A Sagittarii | 4.9 | 7 41 | —1.9 | —0.4 | 80 |
| G | 28 | 290 B. Aquarii | 6.3 | 7 23 | —1.1 | +2.1 | 28 |

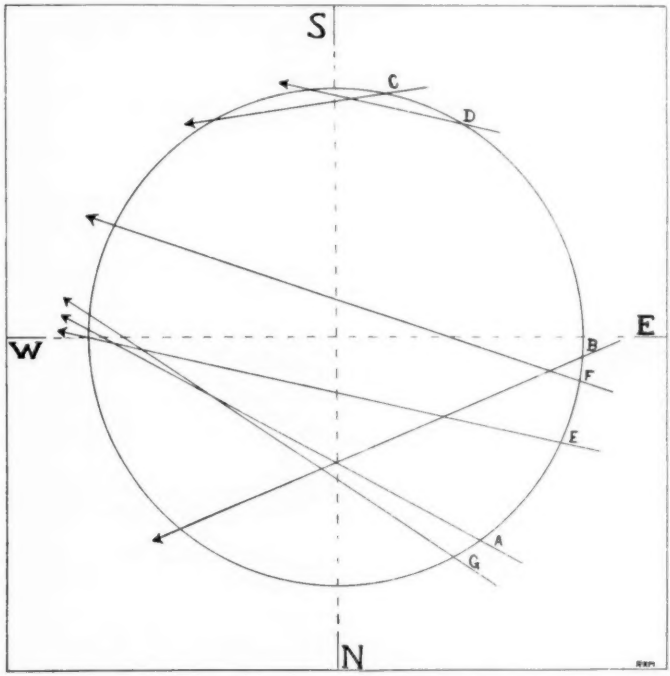



DIAGRAM OF OCCULTATIONS FOR JUNE, 1929, AT AMHERST, MASS.
(As seen in an inverting telescope.)

The G.C.T. of the occultation at some other station within 300 miles of Amherst may be easily found from the coefficients a and b, and the formula

$$\text{G.C.T.} = \text{Predicted G.C.T.} + a\Delta\lambda + b\Delta\phi,$$

where $\Delta\lambda$ is equal to the longitude of the place (to tenths of degrees) minus the

longitude of Amherst (72.5 degrees), and $\Delta\phi$ is equal to the latitude of the place (likewise to tenths of degrees) minus the latitude of Amherst (42.4 degrees). For distances up to 300 miles the error of the formula will rarely exceed 2 minutes. The last column follows the usual convention of denoting the point of disappearance in degrees from the north point of the moon, measured for 360 degrees toward the east. This column applies only to Amherst, although it will be found in many cases that the local position angle differs very little from the value given.

The occultations for June 21 and June 23 are short, barely occuring at Amherst, hence the coefficients a and b are not given. The duration of the former is approximately 31 minutes, and of the latter approximately 25 minutes. Emersion for the former occurs at 209° from the N. point, and for the latter at 186°.

87 Park Avenue, Delaware, Ohio. ROY MARSHALL.

**The Change from 7″ to 6″ for Use with the Occultations Observed in 1929.**—It appears from a preliminary discussion of observations already available that for occultations observed in 1928 the mean error of the tables is very near 6″.4, and that it may be expected to be close to 6″.0 in 1929.

Hence in the reduction of the 1929 occultations it will be best to add 6″.00 (instead of the 7″.00 used in previous years) to the mean longitude of the moon. This requires additions to the tabular right ascension and declination of the moon of

$$+ .182\,\Delta\alpha, \quad + .182\,\Delta\delta,$$

where $\Delta\alpha$, $\Delta\delta$ are the variations per minute at date as given in the Almanacs. (These additions are to be used instead of the $+ .212\,\Delta\alpha$, $+ .212\,\Delta\delta$, previously added.)

Occultations already reduced need not be changed. In publishing or communicating results the amount added should be stated.

ERNEST W. BROWN.

Yale University, 1929 April 3.

**The Total Eclipse of the Sun and the Zodiacal Light.**

There is still among astronomers a disagreement as to whether the Zodiacal Light is an atmospherical phenomenon or whether it is due to reflection of sunlight from cosmic dust. The absence of accurate parallax determinations has left the question unanswered.

But will not a relatively long total eclipse of the sun furnish an opportunity for solving the problem? A total eclipse lasting for four or five minutes is probably dark enough for a keen eye to get a glimpse of the Zodiacal Light, especially if the sun's zenith distance is small. As far as this writer knows there has, however, never been observed any Zodiacal Light during the total eclipses of the sun. But it must be remembered that eclipse observers pass from sunshine into darkness when totality arrives. An observer of such a diffuse and faint light as the Zodiacal Light must first have prepared his eye for this purpose. A rest in an extremely dark room for at least one hour before totality is necessary. And then the observer should come out just before the middle of the eclipse. If a cosmic phenomenon he might then see the Zodiacal Light rather near to the sun. Care should be taken not to stare at the brighter corona.

The eclipse of May 9, this year, will offer favorable conditions for such observations.

S. THORRUD.

Porsgrund, Norway, February 26, 1929.

## METEOR NOTES.

By CHARLES P. OLIVIER.

The first three months of the year are usually those in which most meteor observers have least to report. This is due both to fewer meteors per hour appearing and to harder observing conditions. With the coming of warmer weather in April, along with the Lyrid shower—this year unfortunately spoiled by moonlight—more reports usually arrive. The May Aquarids also attract deserved attention.

While the writer has letters from others reporting work, only R. A. McIntosh of Auckland, New Zealand, and Vincent Anyzeski of New Haven, Conn., have sent in their results. The tables below give briefly their dates of observation, the rates, and the radiants derived from their maps. Mr. McIntosh, having had many years of experience, now derives his own radiants, the writer only glancing over the maps to check the positions. It is our ideal to so train our observers that all can do this for themselves, but generally some years of experience are needed. A certain amount of study in the theory of the subject, as well as observational experience, is absolutely necessary for anyone to know how to derive correct radiants, even from his own work.

R. A. McIntosh, Auckland, N. Z.

| 1929 | Began | Ended | Meteors Min. | Seen | Rate | Factor | Cor. Rate | Notes |
|---|---|---|---|---|---|---|---|---|
| Feb. 11 | 2:11 | 4:10 | 119 | 20 | 10.1 | 1.0 | 10.1 | N. Z. C. T. used. |
| 14 | 2:12 | 4:18 | 126 | 22 | 10.5 | 0.8 | 14.4 | |

Vincent Anyzeski, New Haven, Conn.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mar. 29 | 8:55 | 10:50 | 115 | 12 | 6.2 | 1.0 | 6.2 | E. S. T. used. |
| April 1 | 8:30 | 11:45 | 195 | 21 | 6.5 | 0.7 | 9.3 | |
| 2 | 7:50 | 10:40 | 170 | 21 | 7.4 | 1.0 | 7.4 | |
| 3 | 8:00 | 9:40 | 100 | 10 | 6.0 | 0.7 | 8.3 | |

Radiants by McIntosh.

| No. | Date | α | δ | Meteors | | |
|---|---|---|---|---|---|---|
| 102 | Feb. 10.65 | 206°.5 | —43.4 | 5 | Good | Compare 106 |
| 103 | 10.65 | 212.9 | —67.0 | 3 | Good | |
| 104 | 10.65 | 221.5 | —39.1 | 5 | Good | |
| 105 | 13.66 | 189.0 | —61.0 | 3 | Fair | |
| 106 | 13.66 | 205.5 | —42.2 | 5 | Very Good | Compare 102 |

Radiants by Anyzeski.

| V.A. | | | | | | |
|---|---|---|---|---|---|---|
| 1 | Mar. 29.60 | 143 | +24 | 3 | Fair | |
| 2 | 29.60 | 167 | +15 | 5 | Good | Compare V.A.4 |
| 3 | April 1.63 | 121 | +27 | 3 | Uncertain | |
| 4 | 1.63 | 168 | +12 | 5-6 | Good | Compare V.A. 2 |
| 5 | 2.59 | 166 | +24 | 4 | Fair | |
| 6 | 2.59 | 180 | +61 | 3 | Uncertain | |
| 7 | 2.59 | 193 | +24 | 4 | Fair | |
| 8 | 3.58 | 206 | +32 | 3 | Uncertain | |

We welcome as new active members the following:

Miss Esther B. Means, 8618 Germantown Ave., Chestnut Hill, Pa.

Frank Murray, Box 188, St. Marys, Kansas.

F. C. W. Olsen, 6231 S. Park Ave., Chicago, Illinois.

We also welcome the following members of the *Commission des Etoiles Filantes of the International Astronomical Union,* who are not active members of the American Meteor Society, to associate membership therein:

Madame G. C. Flammarion, Messrs. C. A. Chant, M. Davidson, F. DeRoy, G. M. B. Dobson, H. Grouiller, A. King, P. W. Merrill, W. H. Pickering, J. Svoboda, J. Sykora, and J. Yamamoto.

The other two members of the *Commission,* W. J. Fisher and the writer, are already active members of the A.M.S.

A large number of fireball observations for 1929 have come in. As usual most of them are of different objects. We urge persons even casually interested in astronomy to send us observations of any really bright meteor they are fortunate enough to see. When duplicate observations can be secured, we have a good chance to compute its height.

It is planned to issue a new bulletin with the revised membership list, complete to May 1. Circular letters have been sent to all members who have taken no part in the work during recent years, or in some cases who have never taken a part. It is planned to drop the names of those persons who have not taken the trouble to reply, for it is a useless expense and trouble to keep members on our mailing list who neither pay their dues nor contribute in the slightest way to the work of the Society.

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1929 April 16.

## Monthly Report of the American Association of Variable Star Observers, for the Month of March, 1929.

Although the number of contributors to the accompanying report is somewhat smaller than usual, the total number of observations listed is up to the standard, even exceeding that for the corresponding month of 1928. We welcome a lengthy report from Father McNally of the Georgetown College Observatory. Father McNally has thus proven himself a worthy successor to Father Phillips who made such a fine record for our columns in the two previous years.

As will be noted from an examination of the records, SU Tauri is well below magnitude twelve again, and all who are able to do so, should watch this variable carefully.

*Variable Comments,* Vol. I, No. 16, and Vol. II, No. 1, have recently been issued to our members—this publication circulates exclusively in our ranks of active members. The first mentioned contains a very clear account of the 1928 Fall Meeting at Harvard, and the latter gives a resumé of the work of our newer observers during 1928.

Attention is here called to the approaching meeting of the Association in Washington, D. C., May 17 to 19. With such a complete program as President Pickering and Mr. Stokley have planned, you "can't afford to miss it." We hope to see at this meeting some of our southern members who have not been able thus far to attend our meetings.

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

Jan. 0 = J.D. 2425612; Feb. 0 = J.D. 2425643; Mar. 0 = J.D. 2425671.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| S Scl | T Scl. | — Cas | RZ Per | U Per | o Cet |
| *001032* | *002438a* | 004746b | 012350 | 015254 | *021403* |
| 613 9.1 En | 638 10.3 Dr | 658 11.0 L | 646 9.1 L | 657 7.7 GC | 644 8.9 Ah |
| 625 10.0 Ht | 643 10.7 Dr | 674 10.9 Sf | 651 10.4 Ch | 660 7.9 Ah | 645 9.2 Ah |
| 632 10.0 Ht | 656 11.0 Dr | W Cas | 658 9.9 L | 662 8.0 Ah | 647 9.1 Ah |
| 638 9.9 Dr | RR Scl. | 004958 | 666 9.8 L | 662 8.0 Wy | 650 8.7 L |
| 639 10.0 Sm | *002438b* | 656 9.6 B | 675 10.1 B | 663 8.1 Ah | 651 9.2 Ch |
| 640 10.1 En | 639 13.0 Dr | 656 9.7 Pt | R Psc | 671 7.8 Ah | 651 9.1 Ah |
| 642 10.5 Ht | T Phe | 662 10.1 Wy | 012502 | 672 8.2 Wy | 653 9.1 Ah |
| 643 10.0 Dr | *002546* | 672 10.1 Wy | 621 9.8 Bf | 674 8.6 Bw | 654 8.9 Lg |
| 656 11.3 Dr | 613 10.7 En | 675 10.2 B | 625 10.3 Bf | 678 8.4 B | 654 9.1 Ah |
| X And | 624 11.2 En | 679 10.1 Wy | 636 10.9 Bf | 679 8.0 Wy | 656 9.0 Pt |
| 001046 | 625 12.0 Ht | U Tuc | 643 11.2 Bf | R Ari | 663 9.0 Ah |
| 620 14.4 Bf | 632 12.2 Ht | *005475* | 651 11.5 Ch | 021024 | 664 9.2 BL |
| 625 15.0 Bf | 639 12.2 Dr | 613 10.3 En | 656 11.2 Pt | 644 9.8 Ah | 665 9.1 L |
| 636[13.1 Bf | 639 12.2 Sm | 625 8.7 Ht | RU And | 645 9.8 Ah | 671 9.5 Ah |
| 646[13.4 GC | 640 12.2 En | 626 8.6 En | 013238 | 646 9.8 Ah | 673 9.4 BL |
| 648[13.2 Ch | 642 13.2 Ht | 632 8.6 Ht | 645 11.0 Ch | 647 9.8 Ah | 674 9.3 BL |
| 654[14.1 Lg | 643 12.7 Dr | 639 8.7 Sm | 652 11.1 Lg | 651 10.1 Ah | 677 9.4 BL |
| 658[12.8 B | 656 13.0 Dr | 641 8.5 En | 656 11.0 Pt | 653 10.4 Ah | 679 9.3 BL |
| 680 13.9 Bw | W Scl. | 642 8.7 Ht | 666 10.6 Lg | 654 10.3 Ah | 681 9.2 BL |
| T And | *002833* | Z Cet | 676 10.8 Lg | 655 10.4 Ah | S Per |
| 001726 | 639 13.4 Dr | *010102* | Y And | 656 10.6 Pt | 021558 |
| 648 13.3 Ch | Y Cep | 650 12.8 L | 013338 | 658 10.5 Ch | 547 9.0 GC |
| 656 12.7 Pt | 003179 | 656 12.4 Pt | 645 9.1 Ch | 662 10.8 Wy | 555 9.2 GC |
| 656 13.2 B | 656[13.9 Ch | 666[11.8 L | 652 9.0 B | 671 11.4 Ah | 560 9.7 GC |
| T Cas | 661 12.2 Wn | U Scl. | 656 9.0 Pt | 672 11.7 Wy | 562 9.6 GC |
| 001755 | U Cas | *010630* | 666 9.6 Lg | 676 12.0 Wy | 564 9.0 GC |
| 646 12.1 L | 004047 | 639[13.6 Dr | 673 9.9 Sf | W And | 566 9.4 GC |
| 656 12.2 L | 648[13.2 Ch | U And | 676 9.8 Lg | 021143a | 571 9.5 GC |
| 656 12.1 Pt | 654[12.1 Wn | 010940 | 683 10.7 Sf | 648 11.8 Ch | 582 9.1 GC |
| 658 12.2 Wy | 656 14.6 L | 648 9.9 Ch | X Cas | 652 11.9 B | 622 9.7 GC |
| 666 12.2 L | 680[13.9 Bw | 650 10.6 L | 014958 | 656 11.9 Pt | 640 9.8 GC |
| 672 12.2 Wy | 684[13.2 Sb | 652 9.9 Lg | 656 11.4 B | 666 11.5 Lg | 645 9.2 Ah |
| 675 11.9 B | RW And | 652 10.4 B | 656 12 2 Pt | 674 10.3 Bw | 646 9.4 GC |
| 679 11.9 Wy | 004132 | 665 11.1 L | 672 12.4 Bn | 675 10.5 B | 651 9.2 Ah |
| 682 11.7 Kz | 648[13.2 Ch | 666 10.7 Lg | 675 11.7 B | T Per | 653 9.3 GC |
| R And | 658[13.1 L | 676 11.6 Lg | 679 12.4 Bn | 021258 | 653 9.2 Ah |
| 001838 | V And | UZ And | U Per | 645 8 8 Ah | 655 9.2 Ah |
| 648 10.5 Ch | 004435 | 011041 | 015254 | 651 8.7 Ah | 656 8.8 Pt |
| 653 10.2 Lg | 621 15.0 Bf | 648[12.5 Ch | 556 10.0 GC | 653 8.7 Ah | 657 9.0 GC |
| 656 10.3 Pt | 625 15.1 Bf | 650 13.9 L | 560 10.0 GC | 655 8.7 Ah | 662 9.1 Wy |
| 666 11.0 Lg | 643 14.5 Bf | 665 11.4 L | 562 10.2 GC | 656 8.6 Pt | 672 9.1 Wy |
| 676 12.0 Lg | 656 13.1 B | S Psc | 564 10.2 GC | 662 8.7 Wy | 675 9.3 B |
| 684 12.1 Sb | RR And | 011208 | 566 9.8 GC | 672 8.9 Wy | 679 8.9 Wy |
| S Tuc | 004533 | 650 14.3 L | 571 9.7 GC | 679 8.9 Wy | R Cet |
| *001862* | 621 13.3 Bf | S Cas | 582 9.6 GC | Z Cep | *022000* |
| 613 12.4 En | 625 13.1 Bf | 011272 | 622 8.9 GC | 021281 | 650 11.0 L |
| 615 12.4 Ht | 636 13.0 Bf | 649 12.2 Ch | 640 8.4 GC | 650 14.4 L | 651 10.6 Ch |
| 624 12.4 En | 643 13.1 Bf | 656 11.7 Pt | 645 8.0 Ah | 661 12.0 Wn | 665 9.4 L |
| 625 12.8 Ht | 654 12.8 Lg | 662 12.1 Wy | 646 8.0 GC | 670 13.0 L | RR Per |
| 639 13.2 Sm | 668 11.3 Lg | 672 12.6 Wy | 647 8.0 Ah | 674 12.8 Sf | 022150 |
| S Cet | RV Cas | 679 12.3 Wy | 650 7.6 GC | o Cet | 650 14.3 L |
| *001909* | 004756a | 684 12.9 Sb | 651 8.0 Ah | *021403* | 656[13.8 B |
| 649 8.5 Ch | 648[13.2 Ch | U Psc | 652 7.8 Ah | 613 8.4 En | 674[13.4 Bw |
| 650 8.2 L | 658[14.4 L | 011712 | 653 7.9 Ah | 621 8.4 En | 689[13.4 Bw |
| 652 8.0 Lg | — Cas | 650 14.5 L | 653 7.7 GC | 624 8.6 En | U Cet |
| 656 8.1 Pt | 004746b | 654 13.8 Lg | 655 7.9 Ah | 640 8.6 En | *022813* |
| 666 7.9 L | 656 10.6 Pt | | 656 8.2 Pt | 641 8.5 Sm | 656 12.5 Pt |

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| RR CEP | T HOR | T ERI | R RET | V TAU | T PIC |
| 022980 | *025751* | *035124* | *043263* | 044617 | *051247* |
| 650 12.7 L | 638 10.3 Dr | 651 9.7 Dr | 640 12.0 Sm | 656 13.3 B | 639 8.7 Dr |
| 654 12.4 Lg | 641 10.3 Sm | 656 9.3 Dr | 641 12.2 En | 666 13.0 Lg | 641 8.9 En |
| 656 12.6 Pt | 641 10.2 En | 661 9.0 Dr | 642 12.4 Ht | 676 13.3 Lg | 642 8.8 Sm |
| 668 12.8 Lg | 642 10.5 Ht | W ERI | 643 11.9 Dr | 676 13.5 Pt | 642 9.0 Ht |
| 670 13.0 L | 643 9.8 Dr | *040725* | 656 12.5 Dr | R ORI | 643 8.8 Dr |
| R TRI | 648 9.7 Dr | 639 8.7 Dr | X CAM | 045307 | 648 8.9 Dr |
| 023133 | 651 9.4 Dr | 648 8.8 Dr | 043274 | 646 10.6 L | 651 9.0 Dr |
| 644 9.3 Ah | 656 9.0 Dr | 651 8.9 Dr | 644 11.5 By | 658 11.2 L | 656 9.0 Dr |
| 645 9.2 Ah | 661 9.2 Dr | 656 8.4 Dr | 646 11.2 By | 664 11.5 Wn | 661 9.3 Dr |
| 646 9.3 Ah | U ARI | 661 9.0 Dr | 647 11.0 By | 680 11.6 Wn | NOV TAU |
| 646 9.9 GC | 030514 | R TAU | 650 10.8 By | R LEP | 051316 |
| 650 9.7 GC | 621 14.6 Bf | 042209 | 653 10.5 By | *045514* | 650 13.3 L |
| 651 9.2 Ah | 625 14.5 Bf | 621 10.8 Bf | 654 10.5 By | 615 7.2 Dr | T COL |
| 652 9.2 Ah | 643 14.3 Bf | 643 11.7 Bf | 657 9.6 Ch | 619 7.0 Dr | *051533* |
| 653 9.2 Ah | 674 12.3 Sf | 656 12.7 Pt | 662 10.4 By | 646 8.0 L | 615 10.4 Ht |
| 653 9.3 GC | 683 11.9 Sf | 666 12.1 Lg | 669 9.8 Wy | 658 8.2 L | 616 10.8 En |
| 654 9.1 Ah | X CET | 676 12.5 Lg | 670 10.0 By | 676 8.0 Pt | 625 10.1 Ht |
| 655 9.2 Ah | *031401* | 677 12.9 B | 676 9.2 Pt | 677 8.3 Jo | 627 9.7 En |
| 656 8.7 Pt | 645 10.6 Ch | W TAU | 676 9.4 Wy | 678 9.0 B | 632 9.7 Ht |
| 657 8.9 GC | 650 10.8 L | 042215 | 677 9.3 B | V ORI | 639 9.0 Dr |
| 658 9.0 Ch | 656 10.3 Pt | 653 10.0 Lg | R DOR | 050003 | 639 8.7 Sm |
| 660 9.1 Ah | 662 11.1 Wy | 656 9.3 B | *043562* | 652 13.2 Lg | 641 9.5 En |
| 660 9.2 Sf | 665 11.8 L | 656 9.1 Pt | 615 5.5 En | 666 12.7 Lg | 642 9.5 Ht |
| 663 9.0 Ah | 672 11.6 Wy | 665 9.5 Wy | 625 5.4 Ht | 676 12.1 Lg | 643 8.9 Dr |
| 671 8.5 Ah | 679 11.4 Wy | 666 10.0 Lg | 626 5.3 En | 676 12.1 Pt | 648 8.6 Dr |
| 673 8.3 Sf | 680 12.2 Bw | 676 9.6 Lg | 632 5.0 Ht | 677 12.2 B | 651 8.5 Dr |
| 675 8.3 B | Y PER | 676 10.0 Wy | 639 5.0 Dr | T LEP | 652 8.5 Lg |
| 680 7.6 Wn | 032043 | 677 9.6 Jo | 640 5.2 Sm | *050022* | 656 8.5 Dr |
| 681 7.5 Kz | 656 10.4 Pt | 678 10.1 Al | 641 5.4 En | 643 9.3 Bf | 661 8.2 Dr |
| 682 7.9 Sf | 662 10.6 Wy | 678 9.4 B | 642 5.1 Ht | 676 9.9 Pt | S AUR |
| W PER | 672 10.7 Wy | S TAU | 643 5.0 Dr | 677 9.5 B | 052034 |
| 024356 | 678 10.3 B | 042309 | 648 5.1 Dr | S PIC | 656 10.1 Wy |
| 656 9.9 Pt | 679 10.7 Wy | 621 15.3 Bf | 656 5.2 Dr | *050848* | 672 10.1 Wy |
| 662 10.2 Wy | 681 10.3 Kz | 643 14.8 Bf | R CAE | 616 11.6 En | 676 8.8 Pt |
| 672 10.4 Wy | R PER | 666 12.6 Lg | *043738* | 627 11.7 En | 679 9.8 B |
| 675 9.5 B | 032335 | 676 13.2 Lg | 619 12.0 En | 641 11.8 En | 681 9.9 Kz |
| 677 9.7 Jo | 645 10.6 Ch | T CAM | 625 12.0 Ht | 641 12.9 Sm | W AUR |
| 679 10.4 Wy | 653 10.9 Lg | 043065 | 639 13.5 Dr | R AUR | 052036 |
| 684 10.3 Sb | 656 11.0 Pt | 650 13.6 L | 641 12.0 Sm | 050953 | 644 9.8 L |
| R HOR | 665 12.3 Wy | 653 13.8 Lg | 648 13.5 Dr | 645 9.5 Ah | 655 10.7 L |
| *025050* | 666 12.0 Lg | 670 13.5 L | R PIC | 651 9.5 Ah | 655 10.6 Ch |
| 615 9.7 En | 674 12.1 Bw | 676 13.7 Lg | *044349* | 652 9.5 Ah | 666 11.3 Lg |
| 625 9.2 Ht | 676 12.9 Lg | 679 13.8 Wy | 615 7.6 Ht | 653 9.6 Ah | 674 11.8 Sf |
| 632 8.1 Ht | 676 12.9 Wy | RX TAU | 616 7.5 En | 655 9.3 Ah | 676 11.9 Lg |
| 638 7.4 Dr | 677 12.6 B | 043208 | 625 7.7 Ht | 655 9.4 Ch | 676 12.0 Pt |
| 640 7.1 Sm | 689 13.4 Bw | 649 13.1 Ch | 632 7.7 Ht | 666 9.4 Lg | 677 11.4 B |
| 641 6.9 En | T FOR | 650 13.1 L | 639 7.7 Dr | 669 9.4 Wy | 683 11.9 Sf |
| 642 7.1 Ht | *032528* | 656 13.3 B | 641 8.0 Sm | 671 9.5 Ah | S ORI |
| 643 7.2 Dr | 650 9.4 L | 666 12.5 Lg | 642 8.0 Ht | 676 8.9 Pt | *052404* |
| 648 6.8 Dr | 666 9.6 L | 676 13.1 Lg | 643 7.7 Dr | 676 9.0 Lg | 655 10.4 Wy |
| 651 6.8 Dr | U ERI | 677 13.7 B | 648 7.7 Dr | 678 10.2 Al | 668 9.9 Lg |
| 656 6.3 Dr | *034625* | R RET | 651 7.8 Dr | 681 9.2 Kz | 672 10.2 Wy |
| 666 6.5 Dr | 639 12.2 Dr | *043263* | 656 7.7 Dr | T PIC | 676 10.0 Pt |
| T HOR | 648 13.0 Dr | 615 11.4 En | 661 7.8 Dr | *051247* | 677 9.9 B |
| *025751* | T ERI | 625 11.8 Ht | V TAU | 615 9.2 Ht | 682 10.0 Kz |
| 615 11.2 En | *035124* | 626 12.2 En | 044617 | 616 9.0 En | T ORI |
| 625 11.0 Ht | 639 10.6 Dr | 632 11.9 Ht | 652 12.7 Lg | 625 9.0 Ht | *053005a* |
| 632 10.8 Ht | 648 9.9 Dr | 639 11.9 Dr | 655 13.1 Ch | 632 9.2 Ht | 644 10.8 L |

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| T ORI | RU AUR | SU TAU | χ ORI | Z AUR | NOV PIC |
| *053005a* | 053337 | 054319 | 054907 | 055353 | *063462* |
| 646 10.5 L | 652 13.4 Lg | 669 11.5 Lg | 652 0.8 L | 681 9.7 Pt | 625 7.3 Ht |
| 650 10.3 L | 656 13.2 Wy | 669 12.1 L | 663 0.8 L | 681 9.7 Kz | 632 7.3 Ht |
| 652 10.1 L | 666 13.0 Lg | 671 12.3 L | U ORI | 683 9.8 Pt | 640 7.6 En |
| 653 10.0 L | 669 13.2 Lg | 671 12.0 Pt | 054920a | R OCT | 640 7.5 Sm |
| 655 9.9 L | 672 13.1 Lg | 671 12.3 Wy | 644 8.8 Ah | *055686* | 642 7.4 Ht |
| 655 10.2 Wy | 674[12.8 Sf | 672 12.3 Wy | 645 8.8 Ah | 615[12.0 Ht | S LYN |
| 657 9.4 Pt | 676 13.3 Lg | 672 12.4 Lg | 647 8.9 Ah | 621[12.0 En | 063558 |
| 658 9.8 L | 679[13.4 Wy | 673 12.6 B | 651 9.0 Ah | 625[12.0 Ht | 655 10.6 Ch |
| 659 9.8 Pt | 681[12.4 Kz | 676 12.6 Lg | 652 9.0 Ah | 641[12.0 Sm | 676 10.8 Pt |
| 660 10.0 L | U AUR | 676 12.5 Pt | 653 9.0 Ah | 642 12.0 Ht | 677 10.2 Sf |
| 663 10.0 L | 053531 | 676 12.4 Wy | 654 9.0 Ah | 643 12.3 Dr | X GEM |
| 665 9.8 L | 644 9.1 Ah | 677 12.7 B | 655 9.0 Ah | 656 12.0 Dr | 064030 |
| 666 9.9 L | 645 9.2 Ah | 677 12.6 Sf | 655 9.0 Ch | X AUR | 658 12.7 Wy |
| 666 9.7 Lg | 646 9.2 Ah | 677 12.7 Lg | 658 9.2 Ch | 060450 | 668 13.2 Lg |
| 669 9.8 Lg | 648 9.2 Ah | 678 12.6 Pt | 660 9.2 Ah | 655 12.3 Ch | 671 13.2 Bn |
| 669 9.9 L | 651 9.2 Ah | 679 12.7 Wy | 671 9.5 Ah | 666 11.3 Lg | 672 13.2 Wy |
| 671 9.8 Pt | 652 9.2 Ah | 681 12.8 Pt | 675 9.1 B | 673 11.4 B | 674 13.0 Bw |
| 672 9.9 Lg | 653 9.2 Ah | 681 12.2 Kz | 676 9.6 Pt | 676 10.7 Pt | 677 13.4 Bn |
| 672 10.6 Wy | 654 9.1 Ah | 683 12.7 Pt | 681 10.4 Kz | 676 10.7 Lg | 688 13.1 Bw |
| 675 10.3 B | 655 9.2 Ah | S COL | UW ORI | 677 11.0 B | W MON |
| 676 10.2 Lg | 655 8.6 Ch | *054331* | 054920b | V AUR | *064707* |
| 676 10.6 Pt | 660 9.1 Ah | 615 10.2 Ht | 681 10.6 Kz | 061647 | 676 8.7 Pt |
| 680 10.5 Kz | 663 9.2 Ah | 616 10.1 En | V CAM | 644 11.6 L | 679 9.7 B |
| 681 10.3 Pt | 666 8.9 Lg | 625 10.8 Ht | 054974 | 652 12.0 Lg | Y MON |
| 683 10.6 Pt | 671 9.2 Ah | 627 10.5 En | 646 12.4 L | 655 11.8 L | 065111 |
| AN ORI | 674 9.3 Sf | 632 11.1 Ht | 655 12.5 L | 666 11.4 L | 644 9.3 GC |
| *053005t* | 676 9.4 Lg | 639 11.3 Sm | 660 12.4 Sf | 668 11.8 Lg | 645 9.3 GC |
| 644 11.6 L | 676 9.5 Pt | 641 11.2 En | 668 12.4 Lg | V MON | 646 9.3 GC |
| 646 11.8 L | 679 9.3 B | 642 11.2 Ht | 670 12.9 L | *061702* | 647 9.4 GC |
| 650 11.8 L | 681 9.3 Kz | Z TAU | 674 12.8 Sf | 668 11.2 Lg | 650 9.5 GC |
| 652 11.7 L | SU TAU | 054615a | 676 12.4 Pt | 676 11.4 Pt | 653 9.6 GC |
| 653 11.6 L | 054319 | 620 10.0 Bf | 677 12.8 B | AG AUR | 653 9.3 Lg |
| 655 11.8 L | 644 9.8 L | 643 9.2 Bf | Z AUR | 062047 | 655 9.0 Ch |
| 658 11.8 L | 646 9.8 L | 655 10.4 Ch | 055353 | 644 10.1 L | 668 9.0 Lg |
| 660 11.7 L | 650 10.0 L | 674 11.0 Sf | 644 11.1 By | 655 9.5 L | 676 8.8 Pt |
| 663 11.7 L | 652 9.8 L | 683 11.1 Sf | 646 11.1 By | 666 9.1 L | 677 9.2 GC |
| 665 11.6 L | 652 9.5 Lg | RU TAU | 647 11.1 By | R MON | 683 9.1 GC |
| 666 11.7 L | 653 9.4 Lg | 054615c | 650 11.0 By | 063308 | 686 9.4 GC |
| 669 11.7 L | 653 10.0 L | 620 15.2 Bf | 652 11.0 By | 652 11.6 Lg | X MON |
| S CAM | 654 9.4 Lg | 643[14.7 Bf | 654 10.9 By | 653 11.6 Lg | *065208* |
| 053068 | 655 9.4 Lg | R COL | 656 10.7 Wy | 654 11.5 Lg | 644 7.4 By |
| 645 9.0 Ah | 655 10.8 Wy | *054629* | 657 10.4 Pt | 655 11.5 Lg | 646 7.4 By |
| 647 8.8 Ah | 655 10.3 L | 615 9.0 Ht | 658 10.5 Pt | 656 11.4 Lg | 647 7.4 By |
| 651 8.9 Ah | 656 9.5 Lg | 616 10.0 En | 659 10.2 Pt | 660 11.0 Lg | 650 7.4 By |
| 652 8.7 Ah | 657 10.2 Pt | 625 9.3 Ht | 662 10.5 By | 666 11.0 Lg | 650 7.3 L |
| 653 8.8 Ah | 658 10 8 Wy | 627 10.3 En | 663 10.5 By | 668 11.4 Lg | 651 7.4 By |
| 655 8.8 Ah | 658 10.6 L | 632 9.6 Ht | 670 10.3 By | 669 11.2 Lg | 653 7.5 By |
| 668 8.3 Lg | 659 10.2 Pt | 639 9.5 Dr | 671 10.1 Wy | 669 11.5 Wy | 660 7.6 L |
| 669 8.3 Wy | 660 10.9 L | 639 10 2 Sm | 671 10.0 Pt | 672 11.4 Lg | 662 7.6 By |
| 671 8.7 Ah | 660 9.7 Lg | 641 10.3 En | 672 9.7 Wy | 676 11.0 Lg | 663 7.7 By |
| 676 8.1 Pt | 663 11.1 L | 642 9.6 Ht | 673 9.7 B | 676 11.8 Pt | 666 7.7 Lg |
| 676 8.8 Wy | 665 11.8 L | 643 9.6 Dr | 674 9.6 Al | 676 11.5 Wy | 670 8.1 By |
| 682 8.3 Kz | 665 11.5 Wy | 651 9.7 Dr | 676 9.8 Wy | 677 11.0 Lg | 671 8.1 By |
| RR TAU | 666 11.5 Lg | 656 9.8 Dr | 676 9.6 Pt | 679 11.7 B | 676 7.7 Lg |
| 053326 | 666 11.7 L | 661 10.3 Dr | 677 9.6 B | NOV PIC | R LYN |
| 620 12.6 Bf | 668 11.5 Lg | χ ORI | 678 9.6 Pt | *063462* | 065355 |
| 675 10.9 B | 668 11.9 Wy | 054907 | 679 9.8 Wy | 615 7.4 Ht | 650 12.4 L |
| | 669 12.0 Wy | 644 0.6 L | 680 9.6 Pt | 619 7.4 En | 663 13.1 L |

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| R LYN | $L_2$ PUP | Z PUP | R CNC | T PYX | Y DRA |
| 065355 | *071044* | *072820b* | 081112 | *090031* | 093178 |
| 668 13.1 Lg | 639 4.7 Dr | 620[12.2 Bf | 645 9.9 Ah | 619 [u Dr | 655 10.6 Ch |
| V CMI | 643 4.7 Dr | 631 14.1 Bf | 651 9.9 Ah | V UMA | 665 10.7 L |
| 070109 | 648 4.2 Dr | 634[13.7 Bf | 653 9.8 Ah | 090151 | 669 10.8 Lg |
| 650 13.9 L | 651 4.4 Dr | 636[12.2 Bf | 654 9.8 Ah | 649 10.0 L | 689 12.7 Bw |
| 655 13.6 Lg | 656 4.1 Dr | 643 14.3 Bf | 655 9.8 Ah | 660 10.1 L | R LMI |
| 668 14.0 Lg | 661 3.7 Dr | S VOL | 656 10.0 Pt | 670 10.5 L | 093934 |
| R GEM | RR MON | *073173* | 668 9.4 Lg | 679 10.5 B | 645 11.2 Ah |
| 070122a | 071201 | 625 12.5 Ht | 671 9.7 Ah | W CNC | 652 11.0 Ah |
| 644 7.9 Ah | 650 11.7 L | 640 11.6 Sm | 679 9.1 B | 090425 | 654 11.0 Ah |
| 645 7.9 Ah | 653 11.6 Lg | 642 12.2 Ht | V CNC | 649 13.5 L | 655 11.0 Ah |
| 646 7.9 Ah | 655 11.5 Lg | 648 12.0 Dr | 081617 | 655 13.6 Ch | 656 10.3 B |
| 647 8.0 Ah | 655 11.4 Ch | 656 11.7 Dr | 644 12.3 By | 668 13.0 Lg | 656 11.0 Pt |
| 648 8.0 Ah | 663 11.5 L | 661 12.0 Dr | 655 12.2 Ch | 677 13.0 Sf | 674 10.2 Al |
| 651 8.0 Ah | 666 11.5 Lg | U CMI | 656 12.8 Pt | RX UMA | RR HYA |
| 652 7.9 Ah | 673 11.4 Sf | 073508 | RT HYA | 090567 | *094023* |
| 653 8.1 Ah | 676 10.2 Lg | 650 12.9 L | *082405* | 649 10.8 L | 648[13.8 Dr |
| 654 8.1 Ah | 683 11.1 Sf | 666 13.3 L | 656 8.0 Pt | 665 11.0 L | R LEO |
| 655 8.1 Ah | V GEM | S GEM | R CHA | RW CAR | 094211 |
| 656 7.4 Pt | 071713 | *073723* | *082476* | *091868* | 645 9.3 Ah |
| 657 8.2 Ah | 644 9.5 Ah | 649 13.1 Ch | 615 10.6 En | 621[12.0 En | 646 9.4 Ah |
| 658 8.2 Ch | 645 9.6 Ah | 656 13.0 Pt | 624 9.5 En | 648 13.4 Dr | 647 9.3 Ah |
| 660 8.3 Ah | 646 9.6 Ah | 669 11.8 Wy | 640 8.7 Sm | Y VEL | 651 9.5 Ah |
| 666 8.9 Wd | 647 9.6 Ah | 676 11.0 Wy | 641 8.7 En | *092551* | 652 9.6 Ah |
| 666 8.4 Lg | 650 9.1 L | W PUP | U CNC | 625[12.4 Ht | 653 9.7 Ah |
| 671 8.5 Ah | 651 9.8 Ah | *074241* | 083019 | 640[12.4 Sm | 654 9.7 Ah |
| 672 9.5 Wd | 652 9.7 Ah | 615 11.9 En | 650 11.7 L | 648[12.8 Dr | 655 9.7 Ah |
| 674 9.3 Wd | 653 9.8 Ah | 615 11.9 Ht | 653 11.7 Lg | 661[13.0 Dr | 655 10.1 Ch |
| 674 8.5 Al | 653 9.9 Lg | 625 12.9 Ht | 655 11.6 Ch | R CAR | 656 9.3 Pt |
| 677 9.1 Lg | 654 9.9 Ah | 626 12.6 En | 665 11.4 L | *092962* | 660 9.8 Ah |
| 681 9.5 Wd | 655 9.9 Ah | 640 11.9 Sm | 668 10.7 Lg | 615 6.4 Ht | 664 10.1 BL |
| 683 9.1 Kz | 655 9.9 Ch | 641 11.9 En | 673 10.2 Sf | 619 6.0 En | 671 10.1 Ah |
| Z GEM | 656 10.0 Pt | 642 12.0 Ht | 683 9.6 Sf | 625 5.7 Ht | 672 10.2 BL |
| 070122b | 663 10.3 L | T GEM | 688 9.4 Bw | 626 5.7 En | 674 10.2 BL |
| 656 12.4 Pt | 668 10.5 Lg | 074323 | X UMA | 632 4.8 Ht | 674 10.1 Wd |
| TW GEM | S CMI | 644 11.2 GC | 083350 | 638 4.5 Dr | 677 10.3 BL |
| 070122c | 072708 | 645 11.2 GC | 646[13.0 By | 639 4.4 Dr | 679 10.4 BL |
| 656 8.0 Pt | 653 9.6 Lg | 646 11.2 GC | 656[12.4 Wy | 639 4.2 Sm | 679 9.8 B |
| 683 7.9 Kz | 656 9.9 Pt | 647 10.9 GC | 668[13.3 Lg | 641 4.1 Dr | 681 10.3 Wd |
| R CMI | 661 10.5 Ch | 649 10.8 Ch | 671[13.2 By | 642 4.1 Ht | 682 10.3 BL |
| 070310 | 666 10.2 Lg | 650 11.1 GC | 672[13.4 Wy | 643 4.0 Dr | 683 10.6 Kz |
| 645 10.8 Ah | 669 10.5 Wy | 653 11.2 GC | S HYA | 648 3.9 Dr | 688 10.2 BL |
| 650 10.5 L | 672 10.8 BL | 666 9.5 Lg | 084803 | 651 4.1 Dr | Y HYA |
| 651 10.8 Ah | 674 10.9 BL | 669 9.2 Wy | 653 12.0 Lg | 656 4.5 Dr | *094622* |
| 651 10.6 Ch | 674 10.6 Al | 673 9.2 GC | 655 12.6 Ch | 661 4.3 Dr | 652 6.3 Ch |
| 652 9.6 Lg | 676 10.5 Wy | 674 9.4 Bw | 656 12.4 Pt | X HYA | 656 6.5 Pt |
| 655 9.8 Lg | 677 10.6 Lg | 674 9.2 GC | 668 11.2 Lg | *093014* | Z VEL |
| 660 10.8 L | 677 10.9 BL | 676 9.5 Wy | T HYA | 631 13.0 Bf | *094953* |
| 668 9.9 Lg | 679 11.0 BL | 677 9.1 GC | *085008* | 634 13.0 Bf | 615[12.8 Ht |
| 679 10.6 B | 679 11.1 B | 683 9.1 GC | 650 12.3 L | 652 11.8 B | 621[12.1 En |
| R VOL | 682 11.2 BL | 689 9.4 Bw | 653 12.3 Lg | 653 12.5 Lg | 640[12.1 Sm |
| *070772* | 688 11.4 BL | U PUP | 655 12.5 Ch | 658 11.1 Lg | 648 13.8 Dr |
| 615 13.0 En | T CMI | *075612* | 668 12.4 Lg | 658 12.1 Wy | V LEO |
| 615 13.2 Ht | 072811 | 653 13.5 Lg | 678 12.3 B | 672 11.3 Wy | 095421 |
| 624 13.4 En | 653 11.7 Lg | 655 13.5 Ch | T CNC | 678 10.4 B | 646[11.8 Ch |
| 625 13.4 Ht | 656 11.8 Pt | 689[13.2 Bw | 085120 | Y DRA | 656 12.8 Pt |
| 643 13.2 Dr | 668 11.9 Lg | R CNC | 656 8.1 Pt | 093178 | 677 13.1 Sf |
| | 679 12.1 B | 081112 | 658 8.8 Wy | 649 10.3 L | |
| | | 644 10.1 Ch | 672 9.0 Wy | 653 10.5 Lg | |

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| RV CAR | R UMA | W CEN | T UMA | RU VIR | R CVN |
| *095563* | 103769 | *115058* | 123160 | 124204 | 134440 |
| 621[12.5 En | 657 7.6 Ch | 642 8.4 Ht | 670 8.8 Kl | 646 11.6 L | 652 10.3 Ah |
| 648[13.7 Dr | 657 7.7 Ah | R COM | 671 8.5 Ah | 657 11.2 Pt | 653 10.3 Ah |
| RY LEO | 660 7.7 Ah | 115919 | 672 8.9 Kl | 660 11.6 L | 655 10.2 Ah |
| *095814* | 662 7.6 Ah | 672 11.7 Wy | 672 7.6 Wd | 670 11.7 L | 657 10.2 Pt |
| 670 9.1 Kl | 663 7.5 Ah | 677 10.9 B | 674 8.8 Wd | U VIR | T APS |
| 672 9.1 Kl | 666 8.0 Wd | SU VIR | 678 9.0 B | 124606 | *134677* |
| 680 9.0 Kl | 671 7.5 Ah | 120012 | 680 9.0 Kl | 648 12.4 L | 625 12.3 Ht |
| S CAR | 672 8.0 Wd | 657 11.3 Pt | 681 9.2 Wd | 662 11.7 Ch | 640 11.7 Sm |
| *100661* | 674 7.9 Wd | 672 12.1 Wy | R VIR | 665 11.3 L | 643 10.3 Ht |
| 615 8.0 Ht | 677 8.0 Jo | T VIR | 123307 | RV VIR | 648 10.5 Dr |
| 619 8.0 En | 678 7.9 B | *120905* | 645 9.9 Ah | *130212* | 651 10.3 Dr |
| 625 6.9 Ht | 681 8.0 Wd | 646 9.6 L | 651 9.2 Ah | 648 14.1 L | 656 9.8 Dr |
| 626 7.6 En | V HYA | 657 8.8 Pt | 652 9.1 Ah | 665 11.9 L | 661 9.6 Dr |
| 632 6.8 Ht | *104620* | 660 9.3 L | 653 9.0 Ah | U OCT | Z BOO |
| 638 6.6 Dr | 646 7.3 L | 662 9.2 Ch | 657 8.8 Pt | *131283* | 140113 |
| 639 6.5 Sm | 657 6.3 Pt | 670 9.4 L | 671 8.2 Ah | 624 12.4 En | 649 9.6 L |
| 641 6.4 Dr | 665 6.8 L | R CRV | RS UMA | 625 12.9 Ht | 665 10.5 L |
| 642 6.5 Ht | W LEO | *121418* | 123459 | 640 13.2 Sm | Z VIR |
| 648 6.2 Dr | 104814 | 631 7.9 Bf | 631 13.4 Bf | 641 12.9 En | *140512* |
| 651 6.1 Dr | 631 13.9 Bf | 646 7.6 L | 653 13.3 Lg | 642 13.4 Ht | 648 11.6 L |
| 656 6.2 Dr | 662[12.4 Ch | 657 7.5 Pt | 657 14.0 Pt | 648 13.4 Dr | 665 11.1 L |
| 661 6.2 Dr | RS CAR | 660 7.8 L | 669 13.4 Lg | V VIR | RU HYA |
| Z CAR | *110361* | 670 8.3 L | S UMA | *132202* | *140528* |
| *101058a* | 640[12.3 Sm | SS VIR | 123961 | 648[13.7 L | 648 12.0 Dr |
| 615 11.4 En | S LEO | *122001* | 644 8.0 Ah | R HYA | 656 12.3 Dr |
| 640 12.3 Sm | 110506 | 646 8.5 L | 645 7.9 Ah | *132422* | 661 12.4 Dr |
| 641 11.9 Dr | 653[13.6 Lg | 660 8.4 L | 645 7.9 Lj | 648 7.2 L | R CEN |
| 648 12.1 Dr | 662[12.5 Ch | 670 8.8 L | 646 8.0 Ah | 657 7.0 Pt | *140959* |
| AF CAR | RY CAR | T CVN | 647 8.1 Ah | 665 7.6 L | 615 9.2 Ht |
| *101058b* | *111561* | 122532 | 648 8.0 Ah | S VIR | 625 7.6 Ht |
| 648[12.9 Dr | 648[13.4 Dr | 657 8.7 Pt | 648 7.9 Lj | *132706* | 632 6.8 Ht |
| W VEL | 661[13.4 Dr | Y VIR | 651 8.1 Ah | 657 12.3 Pt | 641 7.0 Dr |
| *101153* | RS CEN | *122803* | 652 8.1 Ah | RV CEN | 642 6.8 Ht |
| 640[12.0 Sm | *111661* | 631 13.4 Bf | 653 8.2 Ah | *133155* | 648 6.6 Dr |
| U HYA | 640 12.1 Sm | 646 12.6 L | 653 8.7 Lg | 648 8.7 Dr | 651 6.4 Dr |
| *103212* | 641 12.2 Dr | 660 11.6 L | 654 8.2 Ah | 661 8.5 Dr | 656 6.5 Dr |
| 649 4.9 L | 648 11.5 Dr | 670 11.2 L | 655 8.2 Ah | T UMI | 661 6.2 Dr |
| 658 5.0 L | 651 11.4 Dr | 672 11.2 Wy | 657 8.2 Ah | 133273 | U UMI |
| RZ CAR | 656 10.7 Dr | T UMA | 657 8.0 Pt | 649 14.3 L | 141567 |
| *103270* | 661 10.0 Dr | 123160 | 658 8.2 Lj | T CEN | 645 11.9 Lj |
| 641 11.0 Dr | X CEN | 644 7.2 Ah | 659 8.4 Lj | *133633* | 659 12.0 Lj |
| 648 10.2 Dr | *114441* | 645 7.3 Ah | 660 8.3 Ah | 632 7.7 Ht | 659 12.0 Pt |
| 651 9.9 Dr | 641 7.4 Dr | 646 7.3 Ah | 662 8.3 Ah | 641 7.9 Dr | 671 11.9 Lj |
| 656 9.8 Dr | 651 7.7 Dr | 647 7.3 Ah | 662 8.6 Kl | 642 7.8 Ht | S BOO |
| 661 9.3 Dr | 656 7.8 Dr | 648 7.4 Ah | 663 8.4 Ah | 648 8.0 Dr | 141954 |
| R UMA | 661 8.0 Dr | 651 7.5 Ah | 666 8.5 Lj | 651 8.0 Dr | 652 11.5 L |
| 103769 | AD CEN | 652 7.6 Ah | 669 8.8 Lg | 656 7.3 Dr | 658 10.8 Pt |
| 644 8.0 Ah | *114858* | 653 7.7 Ah | 670 8.8 Kl | 661 6.7 Dr | 666 10.9 L |
| 645 7.8 Ah | 615 9.1 Ht | 653 7.7 Lg | 671 8.4 Ah | RT CEN | RS VIR |
| 646 7.8 Ah | 625 9.3 Ht | 654 7.7 Ah | 671 8.8 Lj | *134236* | 142205 |
| 647 7.8 Ah | 632 9.5 Ht | 655 7.8 Ah | 672 8.8 Wd | 641 11.1 Dr | 648 10.1 L |
| 648 7.7 Ah | 642 9.7 Ht | 657 7.9 Ah | 672 8.9 Kl | 648 10.8 Dr | 665 11.0 L |
| 651 7.7 Ah | W CEN | 657 7.5 Pt | 674 8.9 Wd | 656 10.1 Dr | V BOO |
| 652 7.5 Ah | *115058* | 660 7.9 Ah | 678 8.9 B | 661 9.8 Dr | 142539a |
| 653 7.5 Ah | 615 11.0 Ht | 662 8.1 Ah | 680 9.1 Kl | R CVN | 645 8.9 Ah |
| 654 7.5 Ah | 625 9.5 Ht | 662 8.0 Kl | 681 9.2 Wd | 134440 | 651 8.9 Ah |
| 655 7.5 Ah | 632 9.2 Ht | 663 7.9 Ah | | 645 10.7 Ah | 652 8.9 Ah |
| 656 7.0 Pt | 639 8.6 Sm | 669 8.6 Lg | | 651 10.4 Ah | 653 8.9 Ah |

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| V Boo | S SER | R CRB | U SER | S OPH | S OCT |
| 142539a | 151714 | 154428 | 160210 | *162816* | *172486* |
| 658 9.0 Pt | 652 12.6 L | 656 6.0 L | 658 9.4 Pt | 680 10.3 Wy | 625[12.8 Ht |
| 662 8.9 Ah | 660 12.8 Ch | 657 6.2 Pt | 670 9.0 Wy | W HER | 640[12.8 Sm |
| 671 8.8 Ah | 665 13.1 L | 657 6.1 Ch | SX HER | 163137 | 651 13.0 Dr |
| 675 8.9 Gb | S CRB | 658 5.9 L | 160325 | 658 12.0 Pt | 656 12.9 Dr |
| R CAM | 151731 | 659 6.2 Lj | 649 9.2 By | 659 12.5 Ch | 661 12.8 Dr |
| 142584 | 658 9.0 Pt | 660 6.1 Ch | 653 8.6 L | R DRA | RU OPH |
| 644 8.8 By | RS LIB | 663 6.2 Pt | 654 9.1 By | 163266 | 172809 |
| 646 8.8 By | *151822* | 663 6.1 L | 658 8.4 Pt | 645 9.9 Lj | 647 9.9 L |
| 647 8.8 By | 649 9.8 L | 665 6.0 L | 663 8.0 Pt | 645 9.6 Ah | 656 9.6 L |
| 651 8.8 By | 665 10.8 L | 666 6.1 L | 663 7.8 L | 648 10.2 Lj | 660 9.4 Ch |
| 653 8.8 By | RU LIB | 667 6.0 L | 670 7.9 L | 651 9.8 Ah | 666 9.0 L |
| 662 8.7 By | *152714* | 670 6.0 L | 670 8.3 By | 653 9.8 Ah | 678 9.0 Pt |
| 670 8.5 By | 649 12.5 L | 671 6.0 Ah | 678 8.0 Pt | 654 10.0 Ah | RT SER |
| 675 8.3 Gb | 658 10.8 Pt | 671 6.2 Lj | 680 7.9 Pt | 655 10.0 Ah | *173411* |
| R Boo | 665 10.8 L | 675 6.0 Gb | RU HER | 658 10.5 Pt | 656 12.1 L |
| 143227 | R NOR | 678 6.1 Pt | 160625a | 659 10.7 Lj | RS OPH |
| 645 12.3 Lj | *152849* | 680 6.1 Pt | 653 13.3 L | 671 11.2 Lj | 174406 |
| 658 11.9 Pt | 648 11.5 Dr | 682 6.1 Pt | 658 13.2 Pt | RR OPH | 678 11.1 Pt |
| 659 11.4 Lj | 656 10.7 Dr | X CRB | 659 13.2 Ch | *164319* | RT OPH |
| 671 10.7 Lj | 661 10.5 Dr | 154536 | 670 13.5 L | 631 9.4 Bf | 175111 |
| 671 10.5 Ah | W LIB | 652 10.4 L | R SCO | 656 9.4 L | 653 11.4 L |
| V LIB | *153215* | 658 10.9 Pt | *161122a* | 658 8.5 Pt | 660 12.0 Ch |
| *143417* | 660 13.8 Ch | 665 11.1 L | 631 11.6 Bf | 666 9.4 L | 666 12.0 L |
| 648 11.2 L | S UMI | R SER | 658 9.8 Pt | S HER | 678 12.3 Pt |
| 665 10.1 L | 153378 | 154615 | S SCO | 164715 | RY HER |
| U BOO | 645 10.2 Lj | 658 8.3 Pt | *161122b* | 658 10.8 Pt | 175519 |
| 144918 | 648 10.3 Lj | V CRB | 631 10.8 Bf | 670 11.0 Wy | 660 12.1 Ch |
| 672 11.7 Wy | 651 9.8 Ah | 154639 | 658 11.9 Pt | RS SCO | R PAV |
| Y LUP | 652 9.8 Ah | 658 9.0 Pt | W CRB | *164844* | *180363* |
| *145254* | 653 10.0 Lg | R LIB | 161138 | 651 11.4 Dr | 651 8.6 Dr |
| 648[14.0 Dr | 654 10.0 Ah | *154715* | 658 11.1 Pt | 661 11.5 Dr | 661 8.0 Dr |
| S APS | 655 9.9 Ah | 652 11.4 L | W OPH | RR SCO | T HER |
| *145971* | 658 9.9 Ch | 659 10.4 Ch | *161607* | *165030a* | 180531 |
| 615[13.4 Ht | 658 9.6 Pt | 665 9.9 L | 656[14.0 L | 651 7.4 Dr | 656 8.7 L |
| 625[13.4 Ht | 658 10.3 Lj | R LUP | V OPH | 661 8.2 Dr | 667 8.4 L |
| 632[12.5 Ht | 659 10.3 Lj | *154736* | *162112* | SS OPH | 678 7.8 Pt |
| 640[12.5 Sm | 666 10.4 Lj | 651 13.5 Dr | 656 7.9 L | 165202 | W DRA |
| 642[13.2 Ht | 669 10.1 Lg | 661 13.5 Dr | 658 7.7 Pt | 658 12.1 Pt | 180565 |
| RT LIB | 671 10.4 Lj | RR LIB | 666 7.7 L | RV HER | 656 12.6 L |
| *150018* | T NOR | *155018* | U HER | 165631 | 666 13.5 L |
| 658 9.2 Pt | *153654* | 652 14.0 L | 162119 | 653 10.5 L | X DRA |
| 675 10.9 Wy | 648 8.0 Dr | Z CRB | 658 10.0 Pt | 658 9.9 Pt | 180666 |
| T LIB | 651 8.0 Dr | 155229 | SS HER | 659 10.7 Ch | 656 11.0 L |
| *150519* | 656 7.8 Dr | 652 14.5 L | 162807 | 666 10.7 L | 666 10.9 L |
| 648 11.4 L | 661 7.6 Dr | 659[13.2 Ch | 656 10.0 L | RT HER | TV HER |
| 658 13.0 Pt | R CRB | RZ SCO | 658 10.0 Pt | 170627 | 181031 |
| 665 12.3 L | 154428 | *155823* | 666 9.1 L | 653 12.9 L | 656[14.0 L |
| Y LIB | 645 6.0 Lj | 658 8.5 Pt | T OPH | 659 13.0 Ch | RY OPH |
| *150605* | 645 6.0 Ah | Z SCO | *162815* | 666 11.8 L | 181103 |
| 648 12.8 L | 645 6.0 L | *160021* | 656 13.0 L | 678 11.1 Pt | 678 9.1 Pt |
| 658 13.8 Pt | 648 6.0 L | 652 11.6 L | 666 11.9 L | Z OPH | W LYR |
| 665 13.3 L | 649 6.0 L | 665 11.8 L | 675 11.4 Wy | 171401 | 181136 |
| S LIB | 651 6.2 Ah | R HER | S OPH | 669 11.1 Wy | 678 12.3 Pt |
| *151520* | 652 6.2 Ah | 160118 | *162816* | 678 11.3 Pt | RV SGR |
| 649 10.2 L | 652 6.0 L | 658 13.5 Pt | 656 10.9 L | RS HER | *182133* |
| 658 9.3 Pt | 653 6.0 L | | 666 10.0 L | 171723 | 651 13.5 Dr |
| 665 9.6 L | 653 6.0 Ah | | 675 10.5 Wy | 678 10.4 Pt | |

VARIABLE STAR OBSERVATIONS RECEIVED DURING MARCH, 1929.

| J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. | J.D.Est.Obs. |
|---|---|---|---|---|---|
| SV HER | RS LYR | TU CYG | RW AQL | RZ CYG | S CEP |
| 182224 | 190933a | 194348 | 200715b | 204846 | 213678 |
| 660 13.4 L | 647[13.4 L | 657 10.6 Ch | 678 9.1 Pt | 557 13.3 GC | 644 10.5 By |
| SV DRA | 658[12.0 Ch | 678 9.4 Pt | RU AQL | 560 13.3 GC | 646 10.5 By |
| 183149 | RU LYR | X AQL | 200812 | 562 13.3 GC | 647 10.5 By |
| 646[13.2 L | 190941 | 194604 | 667 12.0 L | 564 13.3 GC | 651 10.4 By |
| 660 14.2 L | 647 11.9 L | 667[12.3 L | RS CYG | 566[13.2 GC | 651 10.2 Ah |
| RZ HER | 665 12.0 L | 678 14.5 Pt | 200938 | 571 13.3 GC | 652 10.4 Ah |
| 183225 | U DRA | X CYG | 649 7.5 L | R VUL | 653 10.4 Ah |
| 647[13.6 L | 190967 | 194632 | 660 7.7 L | 205923a | 653 10.4 By |
| 660[13.5 L | 647 10.3 L | 660 12.2 Ch | 667 7.6 L | 676 9.6 Wy | 654 10.4 By |
| X OPH | 662 11.5 Ch | 678 10.8 Pt | 678 7.5 Pt | 683 10.7 Pt | 654 10.4 Ah |
| 183308 | 665 11.8 L | S PAV | R DEL | X CEP | 655 10.4 Ah |
| 647 8.6 L | 678 12.2 Pt | *194659* | 201008 | 210382 | 656 9.6 Pt |
| 663 8.4 L | T SGR | 651 7.8 Dr | 667 13.1 L | 551[13.2 GC | 656 10.3 By |
| 678 8.4 Pt | *191017* | 661 7.7 Dr | 676 12.6 Wy | 552[13.2 GC | 662 10.3 By |
| R SCT | 667 11.4 L | RR AQL | 682 13.1 Pt | 555[13.4 GC | 663 10.3 By |
| *184205* | 678 11.5 Pt | *195202* | WX CYG | 556[13.4 GC | 670 10.2 By |
| 645 5.5 Lj | R SGR | 667[12.3 L | 201437b | 557[13.4 GC | RU CYG |
| 658 5.6 Pt | *191019* | RS AQL | 649 10.7 L | 560[13.4 GC | 213753 |
| 660 5.7 L | 662 7.6 Ch | *195308* | 660 10.0 L | 562[13.4 GC | 656 8.9 Pt |
| 663 5.8 Pt | 678 8.0 Pt | 667[12.0 L | 667 11.0 L | 564[13.4 GC | 680 9.9 Wy |
| 666 5.6 L | RY SGR | NOV CYG | 682 9.3 Pt | 566[12.4 GC | RV CYG |
| 678 5.6 Pt | *191033* | 195553 | U CYG | 571[13.2 GC | 213937 |
| NOV AQL | 651 6.3 Dr | 658[12.2 Pt | 201647 | 658 9.1 L | 649 6.8 L |
| 184300 | 661 6.4 Dr | 660[13.2 Ch | 660 11.3 Ch | 670 10.7 L | 656 6.2 Pt |
| 658 11.6 Pt | 678 6.5 Pt | 663[12.4 Pt | 682 9.2 Pt | RS AQR | 658 6.9 L |
| 678 11.6 Pt | TZ CYG | 678[12.2 Pt | ST CYG | *210504* | 667 6.8 L |
| RX LYR | 191350 | Z CYG | 202954 | 550 12.0 GC | R GRU |
| 185032 | 678 10.1 Pt | 195849 | 676[12.3 Wy | 562 11.7 GC | *214247* |
| 678 14.2 Pt | U LYR | 660[12.9 Ch | V VUL | 564 12.0 GC | 613[12.4 En |
| Z LYR | 191637 | 678 12.3 Pt | 203226 | 566 12.0 GC | 624[12.4 En |
| 185634 | 678 9.7 Pt | SY AQL | 683 8.7 Pt | 571[11.7 GC | 639[11.6 Sm |
| 647 10.1 L | TY CYG | 200212 | S DEL | T CEP | RZ PEG |
| 663 10.8 L | 192928 | 652 11.1 L | 203816 | 210868 | 220133b |
| 678 11.4 Pt | 657[11.4 Ch | 666 12.5 L | 671 10.1 Lj | 644 8.2 Ah | 656 10.4 Pt |
| RT LYR | RT AQL | 676 12.1 Wy | 683 10.0 Pt | 645 8.4 Ah | T PEG |
| 185737 | 193311 | 678 11.9 Pt | V CYG | 646 8.3 Ah | 220412 |
| 647 13.9 L | 652 11.5 L | BU CYG | 203847 | 648 8.4 Ah | 649 11.6 L |
| 658[12.0 Ch | 665 11.9 L | 200250 | 660[12.2 Ch | 651 8.7 Ah | Y PEG |
| R AQL | R CYG | 645 11.7 Lj | T DEL | 652 8.7 Ah | 220613 |
| 190108 | 193449 | 671 11.1 Lj | 204016 | 653 8.8 Ah | 625 12.6 Bf |
| 678 9.0 Pt | 659 12.4 Ch | S CYG | 683 8.6 Pt | 654 8.7 Ah | RS PEG |
| V LYR | 678 11.5 Pt | 200357 | V DEL | 655 8.8 Ah | 220714 |
| 190529a | TV AQL | 660 12.8 Ch | 204318 | 656 8.5 Pt | 625 14.0 Bf |
| 647[13.8 L | 193509 | 678 11.0 Pt | 549[13.2 GC | 657 9.0 Ch | X AQR |
| RW SGR | 660 13.0 L | S AQL | 551[13.2 GC | 660 8.8 Ah | *221321* |
| *190819a* | 678 14.3 Pt | 200715a | 552[13.2 GC | 662 8.8 Ah | 625 13.8 Bf |
| 678 9.5 Pt | T PAV | 678 11.9 Pt | 555[13.2 GC | 663 8.8 Ah | T GRU |
| TY AQL | *193072* | RW AQL | 556[13.2 GC | 671 9.1 Ah | *221938* |
| 190907 | 625[13.2 Ht | 200715b | 557[13.2 GC | Y PAV | 613 11.1 En |
| 678 10.1 Pt | 641[12.1 Sm | 551 9.6 GC | 560[13.2 GC | *211570* | 627 11.9 En |
| S LYR | 651 13.6 Dr | 552 9.8 GC | 562[13.2 GC | 625 6.2 Ht | S GRU |
| 190925 | 661 13.4 Dr | 555 9.8 GC | 564[13.2 GC | 642 6.4 Ht | *221948* |
| 658[12.3 Ch | RT CYG | 556 9.9 GC | RZ CYG | W CYG | 624 12.8 En |
| 670[12.6 Wy | 194048 | 557 9.9 GC | 204846 | 213244 | 627 12.2 En |
| X LYR | 645 9.7 Ah | 560 10.0 GC | 551 13.2 GC | 644 5.7 L | 639 12.2 Sm |
| 190926 | 653 10.3 Ah | 562 10.2 GC | 552 13.2 GC | 649 5.8 L | 639 12.3 Dr |
| 678 8.8 Pt | 654 10.3 Ah | 564 10.5 GC | 555 13.2 GC | 658 5.8 L | |
| | 678 10.6 Pt | 571 10.6 GC | 556 13.3 GC | 667 6.0 L | |

## Variable Star Observations Received During March, 1929.

RV Peg
222129
646 10.4 L
658 10.3 L

S Lac
222439
643 8.8 L
656 9.5 Pt
658 9.8 L

R Ind
*222867*
639 12.5 Dr
648 13.5 Dr

T Tuc
*223462*
613 10.2 En
624 10.2 En
625 10.2 Ht
632 9.0 Ht
638 9.2 Dr
639 9.0 Sm
641 8.7 En
642 9.1 Ht
648 8.2 Dr
656 7.9 Dr

R Lac
223841
648 9.8 L
656 9.8 Pt
658 10.2 L

S Aqr
*225120*
560 9.1 GC
562 9.1 GC
564 9.1 GC

RW Peg
225914
621 12.5 Bf
625 12.5 Bf
636 11.7 Bf
648 10.6 Ch

V Cas
230759
645 10.1 Ah
653 10.3 Ah
656 10.1 Pt

W Peg
231425
654 12.2 Lg

V Phe
*232746*
613 12.0 En
624 10.6 En
625 10.6 Ht
632 10.2 Ht
638 9.6 Dr
639 9.7 Sm
640 9.8 En
642 9.7 Ht
648 9.4 Dr

Z And
232848
656 9.6 Pt
679 10.0 Bw

ST And
233335
653 10.7 Lg
656 11.1 Pt

R Aqr
*233815*
550 8.9 GC
555 8.9 GC
556 8.9 GC
557 8.9 GC

R Aqr
*233815*
559 9.0 GC
560 9.0 GC
562 9.0 GC
564 9.0 GC
615 8.9 En
625 9.1 Ht
653 8.9 Lg
654 8.8 Lg

Z Cas
233956
648 13.7 L
652[13.5 B
654[14.4 Lg
658 14.4 L

RS And
235048
545 8.5 GC
555 8.5 GC
564 7.6 GC
571 8.3 GC
640 8.7 GC
646 8.8 GC
650 9.0 GC
657 8.4 GC

RR Cas
235053
652[13.5 B
672[13.1 Bn
680[13.1 Bn

R Phe
*235150*
639 13.6 Dr
648 13.3 Dr
656 13.1 Dr

R Tuc
*235265*
613[12.9 En
624[12.9 En
639[12.9 Sm
641[12.9 En

R Cas
235350
645 9.1 Ah
649 8.8 Ch
651 9.2 Ah
652 9.2 Ah
653 9.2 Ah

R Cas
235350
654 9.3 Ah
655 9.3 Ah
658 9.1 B
669 9.3 Ah
675 9.3 B
682 9.6 Kz

Z Peg
235525
648 12.4 Ch
656 12.9 Pt

Y Cas
235855
646 11.7 L
649 11.6 Ch
658 11.7 B
658 11.9 L

SV And
235939
654 13.3 Lg
656 13.0 Pt
679[13.1 Bw

## Rapidly Varying Irregular Variables

005840 RX Andromedae—
5659.6[11.0 Pt
5671.7 10.8 Pt

010884 RU Cephei—
5650.4 8.7 L
5663.4 8.6 L

060547 SS Aurigae—
5620.4 14.2 Bf
5621.1 14.2 Bf
5625.1 14.4 Bf
5628.1[13.8 Ch
5631.4 14.8 Bf
5636.1[13.9 Bf
5643.2 14.4 Bf
5644.3 13.9 L
5645.8[13.0 GC
5646.4 14.4 L
5647.6 14.1 L
5648.6[13.3 L
5649.3 14.4 L
5649.6 13.9 L
5650.3 13.3 L
5650.7 13.1 GC
5652.2 12.8 L
5652.7 13.2 Lg
5653.3 13.0 L
5653.6 13.3 L
5653.7 13.6 Lg
5654.7 13.7 Lg

5676.7 12.6 Pt
5681.7[11.0 Pt

5670.6 8.8 L

5655.2 14.1 L
5655.8 13.9 Lg
5656.2 14.1 L
5656.8 14.2 Lg
5657.8[12.6 Pt
5658.3 14.5 L
5659.6[12.0 Pt
5660.3 14.2 L
5660.6[12.9 L
5663.3 12.9 L
5665.3 12.1 L
5665.5 12.3 Wy
5666.3 12.0 L
5666.6 11.3 Lg
5666.9 11.1 Lg
5667.6 11.6 L
5667.6 11.5 GC
5668.6 11.0 Wy
5668.7 11.0 Lg
5669.2 10.9 L
5669.5 11.4 Wy
5669.7 11.2 Lg

060547 SS Aurigae—
5670.6 11.6 L
5671.4 12.0 L
5671.6 12.1 Wy
5672.6 12.8 GC
5672.7 13.0 Wy
5672.8 12.0 Lg
5673.6 13.7 B
5673.7 13.3 GC
5674.6 13.5 Bw
5674.7[13.3 GC
5676.7 13.2 Lg

074922 U Geminorum—
5621.2 14.0 Bf
5625.1 13.9 Bf
5631.4 14.0 Bf
5634.4[13.7 Bf
5643.2 13.9 Bf
5644.2 13.6 L
5645.3 13.6 L
5646.4 13.8 L
5646.7 13.5 GC
5647.7 13.7 GC
5649.1 14.1 Ch
5649.6 13.8 L
5650.4 13.8 L
5650.7 13.3 GC
5651.1 13.8 Ch
5652.3 13.7 L

5676.7[12.6 Pt
5677.6 13.9 B
5678.8[12.6 Pt
5679.6[13.3 Wy
5680.8[12.6 Pt
5681.7[12.6 Pt
5682.7[13.3 GC
5683.7[13.3 Kz
5686.7[13.3 GC
5689.6[13.0 Bw

5652.6 13.5 B
5652.7 13.9 Lg
5653.3 13.7 L
5653.6 13.7 GC
5653.7 13.7 Lg
5654.7 13.6 Lg
5655.1 13.8 Ch
5655.8 13.8 Lg
5656.8 13.5 B
5656.8 13.8 Lg
5657.8[13.3 Pt
5658.3 13.6 L
5658.6 13.6 B
5659.6[11.2 Pt
5660.3 13.6 L
5660.8 13.7 Lg

RAPIDLY VARYING IRREGULAR VARIABLES

| Star | J.D. | Est. | Obs. | J.D. | Est. | Obs. |
|---|---|---|---|---|---|---|
| 074922 U GEMINORUM— | | | | | | |
| | 5662.4 | [11.4 | Ch | 5674.6 | 13.4 | GC |
| | 5663.3 | [11.4 | L | 5676.5 | 13.6 | Wy |
| | 5665.3 | [12.4 | L | 5676.7 | [13.3 | Pt |
| | 5666.3 | [13.3 | L | 5676.7 | 13.4 | Lg |
| | 5668.6 | 13.5 | Lg | 5677.6 | 13.9 | B |
| | 5669.2 | 13.7 | L | 5677.6 | 13.9 | GC |
| | 5669.6 | 13.6 | Wy | 5677.7 | 13.5 | Lg |
| | 5669.7 | 13.4 | Lg | 5678.8 | [13.3 | Pt |
| | 5671.7 | [13.3 | Pt | 5679.6 | 13.6 | Wy |
| | 5672.5 | 13.5 | Wy | 5680.8 | [13.3 | Pt |
| | 5672.7 | 13.5 | Lg | 5681.7 | [12.4 | Pt |
| | 5673.6 | 13.5 | B | 5682.7 | [12.3 | Pt |
| | 5673.7 | 13.6 | GC | 5683.6 | 13.9 | GC |
| 081473 Z CAMELOPARDALIS— | | | | | | |
| | 5644.3 | 11.6 | L | 5660.6 | 11.4 | L |
| | 5646.4 | 11.7 | L | 5662.7 | 11.3 | L |
| | 5646.6 | 11.6 | L | 5663.4 | 11.7 | L |
| | 5647.6 | 11.5 | L | 5665.2 | 11.5 | L |
| | 5648.7 | 11.4 | L | 5666.2 | 11.7 | L |
| | 5649.6 | 11.5 | L | 5667.6 | 11.4 | L |
| | 5650.3 | 11.7 | L | 5668.8 | 11.3 | Lg |
| | 5652.2 | 11.7 | L | 5669.3 | 11.7 | L |
| | 5653.3 | 11.7 | L | 5669.8 | 11.2 | Lg |
| | 5655.2 | 11.8 | L | 5670.6 | 11.4 | L |
| | 5656.2 | 11.6 | L | 5672.8 | 11.7 | Lg |
| | 5656.6 | 11.5 | L | 5676.8 | 11.6 | Lg |
| | 5658.3 | 11.8 | L | 5677.8 | 12.2 | Lg |
| | 5660.3 | 11.7 | L | | | |
| 094512 X LEONIS— | | | | | | |
| | 5644.3 | [13.3 | L | 5646.6 | [14.2 | L |
| | 5644.6 | [14.2 | L | 5647.6 | 12.9 | L |
| | 5645.3 | [13.9 | L | 5648.6 | 12.1 | L |
| | 5645.7 | [13.0 | L | 5649.6 | 12.4 | L |
| | 5646.4 | [14.0 | L | 5650.4 | 12.8 | L |
| 094512 X LEONIS— | | | | | | |
| | 5652.4 | [14.2 | L | 5664.3 | [11.8 | L |
| | 5653.6 | [14.7 | L | 5666.3 | [12.0 | L |
| | 5656.6 | [14.2 | L | 5667.6 | 12.3 | L |
| | 5658.3 | [13.9 | L | 5669.3 | 12.1 | L |
| | 5660.3 | [13.9 | L | 5670.6 | 12.1 | L |
| | 5660.6 | [13.0 | L | 5671.6 | [12.3 | L |
| | 5663.4 | [13.0 | L | | | |
| 202946 SZ CYGNI— | | | | | | |
| | 5658.9 | 9.0 | Pt | 5678.9 | 9.0 | Pt |
| | 5659.6 | 9.0 | Pt | 5680.8 | 9.4 | Pt |
| | 5663.9 | 9.2 | Pt | | | |
| 213843 SS CYGNI— | | | | | | |
| | 5560.6 | 12.0 | GC | 5653.3 | 8.6 | L |
| | 5562.6 | 11.7 | GC | 5654.3 | 8.3 | Ah |
| | 5564.6 | 12.0 | GC | 5655.2 | 8.6 | L |
| | 5566.6 | 12.0 | GC | 5655.3 | 8.5 | Ah |
| | 5571.6 | 11.7 | GC | 5655.3 | 8.6 | Ah |
| | 5644.2 | 12.2 | L | 5656.2 | 8.9 | L |
| | 5644.2 | 11.8 | Ah | 5657.5 | 9.0 | Ch |
| | 5644.2 | 11.9 | Lj | 5658.2 | 9.6 | L |
| | 5645.2 | 11.9 | Lj | 5658.5 | 9.6 | Wy |
| | 5645.3 | 11.9 | Ah | 5658.9 | 10.0 | Pt |
| | 5646.2 | 11.8 | Lj | 5660.3 | 10.9 | L |
| | 5646.3 | 11.8 | Ah | 5662.7 | 11.4 | L |
| | 5646.3 | 12.2 | L | 5662.5 | 11.6 | Ch |
| | 5648.2 | 11.8 | Lj | 5662.5 | 11.5 | Wy |
| | 5648.3 | 11.8 | Ah | 5663.9 | 11.7 | Pt |
| | 5649.2 | 12.1 | L | 5665.7 | 11.5 | L |
| | 5650.3 | 10.9 | L | 5666.7 | 11.5 | L |
| | 5650.7 | 10.9 | Lj | 5667.7 | 11.7 | L |
| | 5651.3 | 9.6 | Ah | 5669.9 | 11.6 | Wy |
| | 5652.2 | 8.9 | L | 5675.9 | 11.7 | Wy |
| | 5652.4 | 8.6 | Ah | 5678.9 | 11.8 | Pt |
| | 5653.3 | 8.3 | Ah | 5680.0 | 11.7 | Wy |

SUMMARY OF OBSERVATIONS, MARCH, 1929.

| Observer | Initial | Vars. | Observations | Observer | Initial | Vars. | Observations |
|---|---|---|---|---|---|---|---|
| Ahnert | Ah | 32 | 239 | Jones | Jo | 4 | 4 |
| Allen | Al | 6 | 6 | Lacchini | L | 130 | 359 |
| Bappu | Bf | 26 | 47 | Leiner | Lj | 10 | 33 |
| Beyer | By | 7 | 50 | Logan | Lg | 63 | 166 |
| Bigelow | Bw | 15 | 20 | Peltier | Pt | 173 | 216 |
| Boutell | BL | 3 | 19 | Smith, F. W. | Sf | 15 | 24 |
| Bouton | B | 60 | 74 | Smith, W. H. | Sm | 38 | 38 |
| Brown | Bn | 3 | 6 | Soberanes | Sb | 3 | 3 |
| Chandra | Ch | 91 | 98 | Webb | Wd | 6 | 17 |
| Dartayet | Dr | 61 | 185 | Whitney | Wy | 49 | 110 |
| Ensor | En | 35 | 76 | Wilson | Wn | 5 | 6 |
| Gaebler | Gb | 3 | 3 | Georgetown | GC | 17 | 135 |
| Houghton | Ht | 36 | 101 | Coll. Obs. | | | |
| Kohl | Kl | 3 | 11 | Totals | | 27 | 366 | 2065 |
| Kurtz | Kz | 19 | 19 | | | | |

April 8, 1929.

LEON CAMPBELL, Recording Secretary.

## COMET NOTES.

By G. VAN BIESBROECK.

Unless an unexpected cometary visitor is found these days, the month of May will be practically void of comets.

In the first days of the month COMET 1929 *a* (SCHWASSMANN-WACHMANN) may still be seen in the constellation of Gemini near the region occupied by the planet Mars, but its decreasing brightness will limit the visibility to the larger instruments. It is doubtful if it will be seen yet after the next lunation, because it will have moved then far into the western evening sky. The most recent measure of its position secured by the writer was on April 14. The brightness was estimated somewhat fainter than $13^M$ on that night and the correction to the ephemeris given on p. 245 of the April number was:

$$(O-C) \text{ on April } 14 \quad \Delta\alpha = -20^s, \quad \Delta\delta = 0'.0.$$

On the same night COMET 1927 *d* (STEARNS) was again recorded photographically with the 24-inch reflector. It shows a well-defined image of magnitude 16 and gives as correction to the ephemeris on p. 57 of the January number:

$$(O-C) \text{ on April } 14 \quad \Delta\alpha = -5^s, \quad \Delta\delta = +0'.4.$$

The ephemeris will therefore enable observers with large instruments to locate the object without difficulty. But neither of these comets will be visible in ordinary instruments.

In No. 408 of the *Lick Observatory Bulletin*, N. T. Bobrovnikoff makes an interesting contribution to the problem of the disintegration of comets. A gradual transformation of comets into meteors has been suspected ever since the connection between these two classes of objects has been noticed. It seems now fairly safely established that the emission of material under the form of a *coma* and especially of a tail means a slow dispersion into meteors. In order to find a clue to this unstable condition N. T. Bobrovnikoff investigates the correlation between the brightness of periodic comets and their orbital elements. Making use of the elements of 94 comets for which elliptic orbits have been deduced, ranging from the sharply defined short periods to the more uncertain periods of the order of a million years, he finds a strongly marked linear correlation between the present brightness, reduced to unit distance from both Sun and Earth, and the logarithm of the area of the orbit. The correlation is nearly as striking when the period of revolution is used instead of the area of the orbit. The author uses these considerations for securing an indication of the upper limit of the age of comets. In the case of Encke's comet a decrease of one magnitude in a century seems to result from the last century's observations. Starting from this information and making reasonable assumptions as to the probable original brightness, the author finds that this comet cannot have been in existence for more than one million years. Although the data leading to this estimate are very uncertain it must be inferred that the life-time of a comet is of a duration less than a thousandth of the age of the Earth. Comets and planets would therefore not have originated at the same time. As a tentative explanation the author suggests that comets have been captured by the Sun and "that they are vestiges of a nebula through which our solar system passed comparatively recently."

Williams Bay, Wisconsin, April 23, 1929.

## NOTES FROM AMATEURS.

### Naked-Eye Visibility of Mercury.

In connection with my article on the naked-eye visibility of Mercury published in POPULAR ASTRONOMY, July, 1928, I wished to compare more fully the conditions in the southern and northern hemispheres. Consequently, I went through the times of rising and setting for the whole of 1926 and obtained the results in the following table. The table gives the number of days on which Mercury rose before the sun or set after the sun by more than an hour, for Melbourne and for the same latitude in the northern hemisphere.

| | ——Morning—— | | ——Evening—— | |
|---|---|---|---|---|
| Interval | South Lat. | North Lat. | South Lat. | North Lat. |
| 61- 75 mins. | 33 | 16 | 12 | 27 |
| 76- 90 " | 24 | 28 | 13 | 22 |
| 91-105 " | 11 | 18 | 17 | 22 |
| 106-120 " | 10 | 11 | 25 | 0 |
| 121-135 " | 21 | 0 | 22 | 0 |
| Totals | 99 | 73 | 89 | 71 |

The remarkable difference in the conditions is especially shown in the case when the interval is more than an hour and three-quarters, and particularly in the evening apparitions.

I found again this year as last that the first night that I saw it after superior conjunction was when it set just an hour after the sun, but I am not yet satisfied about the last night before inferior conjunction.

This year (1928) at its most favorable appearance I saw it first on August 29, and last on October 13, showing that it possessed naked-eye visibility on at least 46 successive evenings. I might add that this result is not in the least due to specially good eyesight.

R. J. A. BARNARD.

### Groups for the Study of Astronomy.

The following classes are now being conducted by the Amateur Astronomers Association for members only at the American Museum of Natural History:

| Leader | Evening | Subject |
|---|---|---|
| Mr. C. A. Federer, Jr. | Every Tuesday 7:30 to 9:00 P.M. | Learning the Constellations |
| Mr. S. L. Toplitz | 2d & 4th Tuesdays 8:00 to 9:30 P.M. | Location of Prominent Constellations |
| Miss Jean Conklin | Every Wednesday 7:15 to 8:15 P.M. | General Astronomy |
| Mr. Frank Reh | 1st & 3d Wednesdays 7:15 to 8:15 P.M. | The Stellar Universe, Nebulae, etc. |
| Mr. Paul Shogren | 2d & 4th Wednesdays 8:00 P.M. | Elementary and General Astronomy |
| Mr. Cornelius Wolff | Every Thursday 8:15 P.M. | Light and Later Elements of Physics as Applied to Astronomy. |

Telescopes, apparatus, stereopticon, charts, blackboards, etc., are used.

Regular meetings of the Amateur Astronomers Association every first and third Wednesdays of the month at 8:15 P.M.

DR. CLYDE FISHER, *President.*
MISS M. LOUISE RIEKER, *Secretary.*

**An Amateur Society** has been formed in Denver under the name of The Denver Adult Astronomers Society, which, as far as we know, is the first association of non-professional astronomers organized here. The organization meeting took place on the evening of March 21, in a green-house, and, as the sky was gray and cloudy, the evening was spent in lively discussion on various topics. Ways and means were discussed on reaching others interested, and it was decided that we try and secure free publicity in the way of news events in the local press, and also of securing a permanent meeting place. Our aims and purpose are probably similar to other organizations of this kind, namely, self education, the advancement of the science in so far as we are able to do so, and the spreading of interest in astronomy amongst the laymen. It will be our purpose to get, not so much a large membership, as one with really enthusiastic workers.

The writer would appreciate hearing from others with experience in forming such associations, as they could be of real assistance in guiding us.

H. A. Grout.

4224 Clay Street, Denver, Colorado.

## Planets Observed.

Popular Astronomy of January, 1913, has a colored frontispiece entitled, "The Moon, Venus, Jupiter, and Mercury," with the note, "Observed at $5^h\ 3^m$ P.M., on Monday, November 11, 1912, by Prof. Luis G. Leon." Following it was an article, "Congregation of Planets in the Western Sky during Twilight, Nov. 11, 1912." This was seen outside Mexico City.

While not comparable with the striking grouping referred to above, I observed an interesting planetary aspect, Sunday evening, January 20, this year. At Fort Greene Park, Borough of Brooklyn, New York City, right after sunset, between 5:30 and 6:10 P.M., in the clear, cold, western sky, I observed Mercury low down in the sunglow, 2° above the electric sign of the new Paramount Moving Picture Theatre; higher up in the bright twilight which filled the sky was Venus, while in the zenith were Jupiter and the moon at first quarter. At 5:45 P.M., Mars made its appearance through the waning twilight east of the zenith. At 6:30 P.M., with the darkening of the sky, I picked up Uranus between Venus and Jupiter in my 80 mm Steinheil telescope, 25 power, and at 10:00 P.M. I picked up Neptune east of Regulus in the eastern sky in the telescope. Had I looked the following morning before sunrise I would have seen Saturn in the eastern sky. Thus I would have observed all the planets of our solar system (except the earth) between sunset and sunrise of one night. I did not succeed in persuading myself that I could see Mercury with the naked eye that evening or any of the five or six following evenings that I observed it, but several passers-by said they could plainly see it. However, in my telescope its golden disk gleamed beautifully serene.

Elisha E. Cockefair.

351 Adelphi Street, Brooklyn, N. Y., January 31, 1929.

## Terrestrial Telescope Pier.

There are a good many celestial objects that can be seen with a small terrestrial telescope, such as the seas and craters on the moon, sun-spots, moons of Jupiter, and many other interesting objects, provided the telescope is held steady. But to get good results a tripod or pier is required and that usually means an additional expense of ten or fifteen dollars. In fact I have been able to see the satellites of Jupiter with a glass that only magnified six times, although I have

never seen them without optical aid. I have made several piers for telescopes of the above kind, all more or less satisfactory. The pier shown in the illustration can be made by almost any amateur astronomer at a small cost, say $1.75. The base of the pier as shown is 12x17 inches and two inches thick. The pier is made from a 2x3 and is 51 inches long over all. It is made in two parts, the short pier is adjustable and is 17½ inches long, while the other is 33½ inches long. The level head is 7½x20 inches.

TERRESTRIAL TELESCOPE PIER.

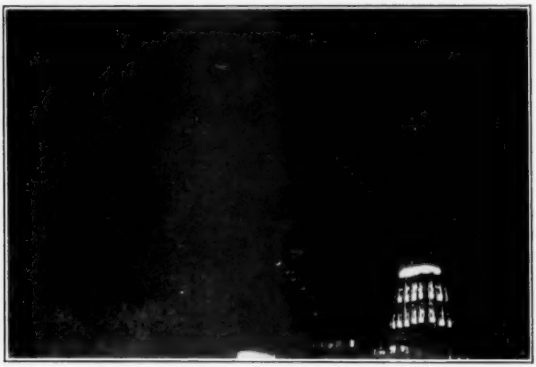
The pier when closed is 53 inches long and extends to 64 inches, that is with level head attached. It can be taken apart and put into a trunk or suit case as it is put together almost entirely with screws. The loops that hold the telescopes are made of leather and are riveted to small strips of sheet metal. All metal parts are gilded while the wood is stained with three coats of rosewood varnish stain.

8 Miller Street, Stamford, Connecticut. HOWARD W. SCOTT.

---

**Celestial Photography by An Amateur.**—I am enclosing herewith three small photographs which if published would probably interest readers of POPULAR ASTRONOMY. No. 1 shows the lighted tower of the new Northern Life Insurance Co. building with the three-day old crescent of the Moon immediately

to the left. The five dots above are the planet Venus at her brightest, and to the left and slightly above are five smaller dots representing Jupiter. No. 2, taken the following night, shows the Moon high above in left hand corner, and Jupiter at left top corner, three dots, and Venus to the right three dots under the big bright spot. A quick fog which developed prevented further exposures on the



No. 1.

two prints as it came between the lighted tower and the camera. No. 1 was exposed between 7:45 and 8:15, March 14, and No. 2 between 8:45 and 9:00 P.M., March 15, when Venus and Jupiter were in conjunction with the Moon.

No. 2.

All three photographs show the diurnal movement of the planets and the Moon but No. 3 gives the best definition and shows the travel of, or apparent motion of, the two planets as regards a vertical structure on the earth's surface over a period of fifty minutes or from 8:05 to 8:55 P.M., March 18.

The tower lights are of the intermittent, mechanically oscillated, color effect type of lighting, that is, through a rheostat connection, the lights are automatical-

ly changed from red, green, and white to a solid white every five minutes. This color changing made it possible to set the camera and expose alternately, one exposure while the red and green were on and the next with the white, which gives definition as seen in a daylight view. One exposure was missed on No. 3, as Venus

No. 3.

passed behind the N.E. corner of the top white light area. This was the last chance to get a photograph of these two planets in such a favorable position for over two years to come.

THOS. W. HALL.

414 Fourth Avenue Hotel, Seattle, Washington.

**Aurora of March 11th.**—The streamers which appeared to the observers at Swarthmore, Pennsylvania, (April, p. 249) to form between Cassiopeia and Polaris and moved steadily to the west, from Auburn appeared to form directly in the east, and passed directly overhead. At the place of origin there seemed to be a curl, as if it were a curtain being unwound. They were astonishingly bright, against a dark sky. At 1:30 A.M. the whole sky appeared as a columned dome, pulsating in waves toward the zenith. The night was cool, calm, but not hazy.

CASPAR R. GREGORY.

Auburn Theological Seminary, Auburn, New York, April 12, 1929.

## Auroral Display.

On the evening of March 11, as I was returning home on the street car, the conductor, knowing me to be interested in all celestial phenomena, asked me to step to the platform and see a strange light in the sky. Upon looking out, I saw a luminous band spanning the sky from west to east bearing a striking resemblance to the beam of a searchlight. On account of the winding street I was unable to get a correct orientation of the light, but when I reached home I had a splendid view of its extent and direction. Stretching from the western horizon about five degrees south of the Pleiades, the band of light extended through the constellations Taurus, Gemini, Cancer, and Leo forming a mighty arch about 120 degrees in length. The edges of the band were well defined and quite regular, the width at the horizon being about three degrees, and expanding as it approached the zenith to about seven or eight degrees.

The sky was clear and moonless, and the arch emitted a silvery sheen like a wisp of fog or mist will in bright moonlight, which gradually faded out at the eastern end, the arch becoming shorter and shorter until it disappeared in the west. The location of the arch caused it to be regarded by many as a display of Zodiacal Light, although its shape and great intensity offer serious objections to that classification. It was probably simply a fine display of the aurora.

When my wife first saw the phenomenon at 10:45 P.M. Pacific Standard Time, she said that the arch extended almost entirely across the sky, reaching well into Virgo. I did not reach home until 11:00 P.M., and watched the spectacle until its disappearance about 11:30 o'clock.

ROBERT E. MILLARD.

1014 Council Crest Drive, Portland, Oregon.

## GENERAL NOTES.

**Miss Anne S. Young,** director of the John Payson Williston Observatory, Mt. Holyoke College, was the speaker at the monthly meeting of the East Bay Astronomical Association held at the Chabot Observatory, Oakland, California, on April 6. Her subject was, "The Story of the Asteroids." Miss Young is spending the year in research at the University of California.

**New Observatory for Baldwin-Wallace College.**—According to a statement by Dr. O. L. Dustheimer, head of the department of astronomy in Baldwin-Wallace College, Berea, Ohio, a new astronomical observatory, which is to cost $100,000, will soon be erected at that institution. The principal instrument is to be a fifteen-inch refracting telescope. The observatory will be designed for the work of teaching astronomy as well as for research.

**Lunar Appulse.**—Although there will be no eclipse of the moon in the year 1929, there will be a lunar appulse on May 23. Mr. Ralph C. Lowe has made the necessary computations and finds that the moon will enter into the penumbra to an extent of 0.97 of its diameter. The times of the phases will be in Greenwich Civil Time:

Beginning, $10^h\,18^m$; Middle, $12^h\,37^m$; Ending, $14^h\,56^m$.

The moon will be in the zenith, at the mid-phase, in latitude $-21°\,28'$, longitude $169°\,28'$ east. From this it is seen that the phenomenon will not be observable in America but should be visible in southeastern Asia.

**The W. J. McDonald Observatory of the University of Texas.**—The contest in the courts of the will of the late W. J. McDonald of Paris, Texas, who left in 1926 almost his entire estate to found an astronomical observatory in connection with the University of Texas, has been settled by a compromise. In place of the $1,200,000 originally bequeathed, a little less than $900,000 is secured to the Observatory by the compromise. The Board of Regents of the University has full power to use this fund at once or later to advance astronomical knowledge in any way that they may deem wise. It being known that Mr. McDonald at times contemplated the accumulation of this fund over a number of years before the actual establishment of the Observatory, the Regents will proceed with plans very slowly and in accordance with advice from the greatest living astronomers.

**200-inch Telescope.**—The designs for the 200-inch telescope, which is to be constructed for the California Institute of Technology with the coöperation of the Mount Wilson Observatory, are being rapidly developed by J. A. Anderson, F. G. Pease, E. P. Burrell, and Russell W. Porter. While it is possible that considerable changes may be necessary before the final form is determined, the present plans call for a reflector built according to the general type of the 60-inch telescope on Mount Wilson.

The tube will be suspended in a fork of massive construction. Roller- and ball-bearings of the present day are sufficiently accurate for use in eliminating friction in the movements of the telescope.

The weights and stresses of the various parts have been calculated in order to make certain of ample rigidity. The tube of the telescope will be about 50 feet long and the ratio of the focal length to aperture about 1 to 3.3. The total weight of the moving parts is estimated at 200 tons. The optical arrangements permit of the use of the Newtonian, Cassegrain (with a hole in the principal mirror), and Coudé forms, all of which have been successfully employed with the 60- and 100-inch telescopes.

Experiments are in progress to determine whether it will be possible to make a quartz disk of such large size. Other possibilities are also being considered. Exhaustive observations of atmospheric conditions at a number of mountain stations in California and Arizona will be carried on for about two years before the site of the new observatory is chosen.

---

**An Interesting Dark Nebula.**— It is now an elementary fact that obscuring clouds or dark nebulae are sometimes constituents of spiral nebulae. An illustration which is an excellent example is rather frequently published, but I have never seen any accompanying text stating specifically that the picture shows a dark nebula, and the ordinary amateur or casual reader misses a most interesting part of the picture. The illustration in question is one of the spiral nebula M. 101 (N.G.C. 5457) in Ursa Major. Probably the best reproduction easily available is the frontispiece to *A Beginner's Star-Book*, by Edgar Gardner Murphy (second edition, G. P. Putnam's Sons, 1923). Another good illustration of this nebula has just appeared in the October number of the *Publications of the A. S. P.*, opposite p. 326. There the dark nebula appears to the right of the center of the picture, and coils downwards.

A little below the center of the plate, encroaching upon one of the bright arms of the spiral, is a distinct dark nebula, which at first glance appears to be anchor-shaped, with the arms to the top. Its shape is also comparable with a T, or with the conventional ram's head sign for Aries. Closer inspection reveals further but fainter branches of the dark nebulosity extending upwards into the brighter parts of the spiral. But what is more intriguing, one gets the impression that the anchor is really a loop, and that the dark nebulosity extends an inch or more across the picture towards the left, as a series of four or five connected loops along a dark lane. This dark lane curves very much as an arm of the spiral would. The impression of the first two loop-like objects, including the anchor-shaped one, is fairly definite; the remaining ones are very vague, and perhaps imaginative. The reader is urged to look closely at the picture, which will tell the story much more quickly than this note can.

The object does not seem to be listed in Barnard's Catalogue of 349 Dark Objects in the Sky (*A Photographic Atlas of Selected Areas of the Milky Way*).

If a detailed description by an experienced astronomer who has access to original plates has not been published, it would certainly be of interest, especially if accompanied by a long exposure made on a large scale. Is this really a coiled or helical dark nebula?

OSCAR E. MONNIG.

Ft. Worth, Texas.

## BOOK REVIEWS.

**The Sun** (Revised edition) by C. G. Abbot. (D. Appleton & Co., New York, 1929. 433 pp. Price $3.50). For some years past the need of an up-to-date book on the sun has been felt by many teachers of astronomy and by others interested in the subject. This need is met in a fairly satisfactory way by the reprinting of Dr. Abbot's well-known book, the first edition of which appeared in 1911. Some parts have been entirely rewritten and certain corrections made in the remainder in order to bring the facts and theories in accord with present knowledge and ideas. We wish the author had had the time to rewrite it completely so that he would have eliminated such expressions as "Recently . . ." when referring to work done before 1911 and would have discussed the solar spectrum on the basis of St. John's revision of Rowland's table instead of on the basis of the original. Aside from these minor faults the new edition of *The Sun* is admirable. The language is simple, the style direct, and the various problems in connection with the sun are treated as fully as need be in a book of this character. We recommend the book as the best of its kind in English at the present time.

E. A. F.

**The Story of the Moon,** by Garrett P. Serviss. (D. Appleton and Co., New York City.)

The desire on the part of the reading public for books relating to astronomy, written in a form intelligible to one who has not made a systematic study of the science, will be well fulfilled by this volume as far as the moon is concerned. In the form of a conversation, rather one-sided, it is true, extending through 236 pages, the writer conveys to the reader a vast amount of interesting and detailed information regarding the present state of our knowledge of this body. The descriptions he gives of the several features on the moon's surface are made vivid and understandable through twenty-two photographs taken so as to exhibit practically all of the phases of the moon through a complete lunation, and five others, showing some particular regions under greater magnification. As intimated above, the book is one which can be highly recommended to those whose interests lead them into the simpler and entertaining fields of astronomy.

**Volkstumliche Himmelskunde,** by Dr. P. Stucker. (William Engelmann, Leipzig, Germany.)

The title of this book, perhaps unfamiliar to some, is simply "Popular Astronomy." The author, writing in German, takes up the usual topics in works of this kind and treats them rather fully. Numerous excellent illustrations are to be found throughout the book. The book concludes with a table of the most important numerical data relative to the sun and the planets. There are also a few maps of the sky which are helpful in identifying the constellations and the brighter stars. One who is sufficiently familiar with the German language will find this volume interesting and instructive.